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INTRODUCTION

By H. B. Richardson

It gives me great pleasure, once again, to take part in the Date Growers' Annual Institute. I believe this is the 41st such Institute.

My first association with the Institute "dates" back to 1935. Those years during the thirties were sort of lean—money and grower interest for anything was awful tight. Somehow, each year a program was put together, the meetings held, and the papers presented were published for permanent record.

I can remember, too, when the question arose: why continue the Institute publication at all? A few of the date grower stalwarts wouldn't give up; so the activity continued. Your attendance here today is proof that today everyone is very glad for this continuation.

Then came the World War II—with that normal year of 1944—very high prices and a very large crop. Everyone was happy. Normalcy had returned at last. Dr. Harry Wellman, then head of the Giannini Foundation, University of California, gave a paper at the 22nd Date Growers' Institute entitled, "The Date Situation and Outlook." Many took issue with the report and, according to some people, he was out to wreck the date industry.

For the next few years economic condtions did "slide" considerably for the date growers. Wellman's predictions had come very close to hitting their mark.

Since leaving my post as Farm Advisor here in Riverside County in 1949, I've only kept in casual touch with the date industry. But from what I've been told, the date industry is in a healthy condition and has come a long way, not only production-wise, but market-wise. The date grower is caught up, just like the rest of California agriculture, in a net of ever-increasing production costs. To lower these costs the need is to mechanize as fast as possible and to expand and strengthen markets. Market's competion for the consumer's dollar gets even more keen and what's ahead is not an easy road, but I'm sure that the Date Industry will make the grade.

THE DATE PALM IN CYPRUS

By H. B. Richardson[1]

The date palm has apparently been known in Cyprus for a good many hundreds of years. There has been very little written about the date in Cyprus. I was recently in Rome and I hunted up Mr. V. H. W. Dowson, whom many of you know. I asked Mr. Dowson if he had any information on the date in Cyprus. Going through his file cards, he was able to pick up only one citation in the literature and this was written a good many years ago by an Englishman. And there, the only comments were that they had observed the date palm in many of the villages.

For the most part, the date palm is located in those villages which are predominantly Turkish, although there are isolated palms in a great number of the villages where the populations are of either Greek or mixed Greek and Turkish descent. Individual date palms may be observed in the backyards of many homes in all lower-elevation sections of the island.

In my journeys around the island, the largest number of date palms were noted in the villages of Lefka, Athalassa and Larnaca; although I didn't visit all of the villages, by any means, as there are over 640 of them on the island, I am sure that there are other date palms in other villages, particularly in the warmer, dryer sections of the island.

With water very scarce on the island, I noted that most of the date palms are located in those villages where there has been agriculture of sorts for many generations. This agriculture was, and is, fed by waters coming down mountain canyons or from large springs. There are several of these large springs on the island which support a very intensive and ancient agriculture. I suppose these springs in Cyprus are characteristic of the oasis areas of North Africa. Dry wall terracing for maintenance and making of agricultural land is widely practiced.

As to the varieties of dates, I don't think they can be classed as varieties. Most, if not all, of them are seedlings. I made one inspection trip at the request of a large landowner, together with his manager, to look over some date palms in the Lefka area. It was felt that they might obtain some offshoot material and start a small planting of dates. It was immediately evident that these palms were all different. There were no off-shoots on any of the palms that I noted. I did note that young palms sometimes grew from around the bases, but I presumed that these were largely from seeds that had become lodged. The fruit secured from some of the palms, although still very green, showed, upon cutting, that a good share of it had not been pollinated, as there were no seeds present. Some pollination may be practiced, particularly with palms located in the communal lands that belong to the villages. If so, I did not see any of this activity. I noted that there was always a large number of male palms in all the old plantings, so it was presumed that they trust to nature to take care of their pollination problems. Also, the ground underneath the palms is used for other types of agricultural production, both permanent and annual.

For the most part, these palms are found on what might be classed as fair-to-good soil. Underneath the palms oftentimes citrus was found and, in the case of Athalassa farm near Nicosia the date palms were largely along borders and in what are now livestock pens and runs.

I saw no new palms being set out anywhere in the island. I came to the conclusion after looking around at these miscellaneous seedling palms that this landowner wanting to produce quality dates would do well to go to the North African countries or to California and obtain a group of date off-shoots of known varieties.

I noted that the date fronds were taken off the palms quite regularly. Apparently, they are used for fuel, as fuel is rather scarce on the island. I saw very little evidence of any dethorning and in the ripening bunches there was no effort to pull the date bunches down and tie them to the fronds; most of the bunches observed were sticking up helter-skelter through the main crown leaves of the palms themselves. I would judge the number of leaves per date palm crown to be one-half or one-third the number that is characteristic of the Coachella Valley palm.

Date bunches are cut in toto after they are close to maturity and are hung up in the houses or sheds to ripen. After the dates ripen they are dried to some extent and held for food for the family or sent to market. As in all the middle-eastern countries, barrow cart men and peddlers are much used as sale outlets. In the Turkish quarter of Nicosia and in some of the other village markets I noticed fresh dates for sale. These were largely spread out on boards in small piles and individual fruits were very wide-ranging in size and color and quality. No attempt was made to maintain any sort of sanitation during the selling process.

Cyrpus does not export any dates. In fact, I am told that it imports a

[1] *H. B. Richardson, Viticulture Specialist, Marketing. Observations made during 10 months' residence in Cyprus*: 1962-1963.

certain quantity of dates from North Africa for its own use. It always seemed strange to me that Cyprus imported as much agricultural produce as it did; the island has a rather high level of income compared to Middle-East countries, yet has imported a good many commodities, which it seemed to me, could well be grown within the island.

The island of Cyprus has many problems. The major one at the moment seems to be political. Aside from the political situation, the absence of adequate water supplies and the fragmentation of agricultural land will seriously hamper any large-scale agricultural development. Cyprus will never be a factor or competitor in date production. Probably the two aforementioned things, plus the absence of a really suitable date-growing climate, will rule out any possibility of quantity production of dates for other than domestic or aesthetic purposes.

The following data on Cyprus temperatures will give some indication of the island's possibility for date production:

TEMPERATURE DATA — DEGREES F.[2]

Morphou Goverment Farm
Western Cyprus

Mean Monthly Average Temperature — 1951-1955

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
(Avg. Annual) 64.5	52	53	55	59	66	74	78	79	74	68	60	53
1936-1955 Maximum	73	73	90	94	104	110	106	111	104	105	90	79

Nicosia

Mean Monthly Average Temperature — 1916-1956

(Avg. Annual) 66.0	50	50	55	62	70	78	83	83	78	70	62	53
1916-1957 Maximum	71	79	86	105	106	111	111	112	107	105	91	75

[2]From Govt. Reports. Dec. 1959—"Temperature and Humidity Statistics for the Island of Cyprus".

VIABILITY OF DATE SEEDS IN RELATION TO AGE

By Roy W. Nixon

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That date seeds may retain their viability for several years is well known, but no data have been available as to the maximum length of time. At the U. S. Date and Citrus Station date seeds of different varities and from special pollinations are held for future use. It is time-consuming to make these pollinations and collect the seeds, so it is important to know for how long the seeds may remain viable. Various lots, stored in glass jars, have been held in a basement since 1948. In the summer of 1963 it was decided to test the germination of all accumulated lots to determine when they might be discarded. In this basement storage room, below ground level, temperatures have varied from a minimum of about 50° F. in winter to a maximum of about 85° F. in summer, a range of temperatures much less than that of the air outside where some minimum temperatures in the 20's and maximum temperatures above 110° F. occur every year.

MATERIALS AND METHODS

From each lot of stored seed, 100 were counted out for testing. In a few lots less than 100 were available, but no tests were made unless there were more than 50 seeds. The seeds were given no pretreatment of any kind, but, to facilitate subsequent examination, were placed in small muslin bags. Metal pots, gallon size, were used for germination with about 2 inches of soil in the bottom, a little vermiculite-peat moss mixture over that, then the muslin bag, and above it 2 or 3 inches more of the vermiculite-peat moss mixture. The pots were placed in a lath house on June 13 and watered daily. Germination was checked July 3 to July 15. Air temperatures during this period ranged from 70° to 113° F. Temperatures of the media around the seeds were checked several times and found to range from about 78° to 90° F.

When the percentage of germination was less than 80 percent the ungerminated seeds were put back in the media and checked again August 6-7. Only a few germinated subsequently—1 to 7 percent in 22 lots, mostly 11-year-old seeds. The muslin bags were more or less rotted at the end of 3 weeks and were replaced when testing was thus prolonged.

Seeds were considered to have germinated when the cotyledon had begun to emerge from the germ pore. Observations have indicated that if the cotyledon pushes out even a few millimeters in tubular form this will be followed by the subsequent development of the embryo if environmental conditions are favorable. In some of the oldest seeds the cotyledon sometimes became swollen and protuded for 1 or 2 mm., but instead of forming a definite tube it developed a lateral enlargement of tissue indicative of an abnoral condition and inadequate vitality. These were not counted as germinated.

RESULTS

Germination varied greatly among different lots (Table 1). Even in the 3-year-old seeds the germination of one lot was down to 40 percent. The yearly average of the different lots through 6 years, however, ranged around 80 to 90 percent. The average percentage of germination showed a definite drop after 6 years. The germination of 8-year-old seeds varied from 3 to 91 per cent. Although a few lots of the 11-year-old seeds failed to germinate, one lot germinated 71 percent and the average was 26 percent.

The oldest seeds, and the only ones from before 1952, were those from 1948, 15 years old. In each of the 7 lots from that year a few specimens, ranging from 1 to 12 in number, showed some abnormal swelling and slight protusion of tissue from the germ pore, but no definite tube formation occurred except in one lot in which the cotyledons of 2 seeds extended out about 4 mm. These 2 seeds were first counted as germinated, but because of age and the relatively slight extension of the cotyledon there was some uncertainty, so they were replanted and the cotyledons were subsequently found to have rotted with little further increase in size.

Table 1.—Germination of date seeds as affected by age.

Age yrs.	No. lots	No. vars.	Germination % Max.	Min.	Av.
1	4	4	96	87	93
2	11	8	99	75	89
3	17	7	93	40	78
4	18	10	99	63	87
5	7	6	97	84	92
6	3	3	93	73	83
7	2	2	70	64	67
8	10	4	91	3	61
11	39	27	71	0	26
15	7	6	2?	0	0

In connection with the germination of seeds of different ages some observations were made on other conditions affecting germination. In one test with seed of the Zahidi variety, those put in water at a temperature of 170° F. at time of immersion and left for 24 hours gave no better germination than those left for 24 hours in unheated water, and neither treatment was better than no soaking at all. Seeds from Deglet Noor dates prematurely shrivelled but of almost average size otherwise, germinated 83 percent, which was within the range of those from normal dates. However, one lot of seed from Deglet Noor dates that had been obviously stunted in their development and were only about half normal size germinated only 55 percent as compared with 90 percent germination for seeds from normal fruit.

DISCUSSION

It should be borne in mind that this was not a planned experiment. There were not enough different lots of seeds in many years to make sure that the average germination is representative. However, taken as a whole the results are convincing evidence that under condition of storage similar to those that obtained in this instance, date seeds stored at ordinary air temperature may be expected to give satisfactory germination for as long as 6 years, and that seeds from special pollinations not easily duplicated should be retained at least 11 years. A study of environmental factors conducive to longevity would undoubtedly make it possible to prolong storage beyond that period.

Reasons for the variation between different lots of the same age are not apparent. This variation showed a tendency to increase with time. Variety did not appear to be a factor involved as there was as much variation within varieties as between. For example, in the 11-year-old seeds, in 3 lots of the Menakher variety one germinated 63 percent and the other two 0 and 1 percent. It seems likely that different lots of seed vary in their initial vitality due to differences in the condition of the palm or of the bunch from which they are taken. The influence of nutritional condition is shown, for example, by the poor germination of small seed from stunted fruit as compared with larger seed from normal fruit. Such fruit and seed often occur as the result of a partially broken fruitstalk or strand, and it seems likely that in somewhat the same way the condition of the palm itself might affect the vitality of the seed.

Of the seeds that failed to germinate, as many as 4 to 5 percent in some lots, and 11 percent in one, lacked the germ pore and apparently also the embryo. Rot had destroyed the cotyledons of some seeds either before they started to germinate or after only a few millimeters of extension. Presumably some of these would have developed normally in a medium with less contamination.

SUMMARY

Miscellaneous lots of date seeds were stored at ordinary air temperatures in a dry cellar in 1948, 1952, and yearly from 1955 to 1962. When tested in 1963, the average germination was around 80 to 90 percent up to 6 years of age and some 8-year-old lots were also in this range. At 11 years of age, one lot of seeds germinated 71 percent but the average of 39 lots including 27 varieties was only 26 percent. The 15-year-old seeds failed to germinate.

PRESENT STATUS OF DATE PEST CONTROL STUDIES

By H. S. Elmer

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Date pest studies during 1963 included: 1) the effectiveness of sulfur applied as sprays for the control of the Banks grass mite, *Oligonychus pratensis (Banks),* 2) the effectiveness of malathion sprays for the control of of the nitidulid beetles on soft date varieties, 3) control of the nitidulid beetles using lindane impregnated paper bunch covers, and 4) the protection of date fruit from injury caused by the Apache cicada. The latter is reported under a separate title in this bulletin.

Information obtained in the field and laboratory during 1963 to find better methods of reducing losses caused by Banks grass mites and nitidulid beetles is presented in this report.

Mites

Preliminary tests for the control of Banks grass mites on dates in 1961 indicated that wettable sulfur was comparable to sulfur dusts when applied correctly at dosages of from 6 to 10 pounds per 100 gallons of water (Elmer, 1962). Subsequent tests during 1962 on large acreages gave results comparable to the 1961 results when applied at the same dosages but the mite populations in some commercially treated acreages were not reduced to a sufficiently low level when lower dosages were used or when inadequate coverage was applied.

Commercial wettable sulfur has an excess of wetting agent which causes considerable run-off when applied to dates. A series of plots were sprayed to compare commercial wettable sulfur with dusting sulfur added to the tank mix with a small amount of wetting agent. The results are shown in Table 1.

Table 1. Comparison of the effectiveness of sprayed plots using dusting sulfur plus blood albumen spreader or casein spreader with commercial wettable sulfur sprayed plots and sulfur dust in two date gardens for the control of Banks grass mite.

Plot	lbs./100 gals.	Days Effective
sulfur + B.A.S.[1]	4 + ¼	64+[2]
sulfur + B.A.S.	4 + ¼	64+
sulfur + casein spreader	6 + ¼	64+
sulfur + casein spreader	6 + ¼	64+
wettable sulfur	4	28
wettable sulfur	6	64+
sulfur dust	50[3]	64+

[1]B.A.S.—Blood albumin spreader
[2]No mites present after 64 days.
[3]Sulfur dust applied at the rate of approximately 50 lbs./acre.

Dusting sulfur was added to the spray tank when the water was at the agitator shaft level. The wetting agent, ¼ pound of blood albumin spreader or casein spreader, was added and agitation was continued for a minute before the rest of the water was added to the tank. All sprays were applied with a conventional high pressure citrus sprayer using a shade tree gun at the rate of approximately 100 gallons per 15 trees. The 4 and 6 pound dosage of dusting sulfur used as a spray with either of the two wetting agents added was as effective in reducing mite populations as the 6 pound dosage of wettable sulfur or the sulfur dusted plot. Only the 4 pounds of wettable sulfur did not keep mite populations from returning the length of the test or 64 days. These dosages, 4 and 6 pounds per 100 gallons, represent 12 to 18 pounds on an acre basis compared to 50 pounds of sulfur per acre when used as a dust.

Nitidulid Beetles

Malathion sprays were applied to a series of test plots on two soft date varieties, Khadrawy and Medjool. These tests were devised not only to reduce or prevent beetle infestation in the fruit but also to eliminate the need for removing insecticide residues by washing. Usually dusts are not applied to soft date varieties because the removal of these dust residues by packing house mechanical washing equipment may cause injury to the fruit.

The results are shown in Table 2.

The percentage of beetle-infested fruit is the average number of fruit infested found by cutting open 50 fruit from each of 7 replicated plots for each dosage applied. In the Khadrawy date gardens the plots were over-dusted with malathion 7 weeks after treatment, but at the end of 6 weeks when the first samples were cut, there was a signficant difference between the treated and the untreated plots. This dust was applied because of two rain showers that occured during the sixth week.

Although the beetle infestation was quite high after the 8 week samples were cut from the Medjool plots, the 11.0 percent average infestation found in the plots sprayed with 51.2 ounces of malathion emulsifiable concentrate was considerably less than the 30.0 percent average infested check plots. The 6 lbs. of 25 percent malathion wettable powder plots on the average had fewer infested fruit than the 8 lb. dosage. There is no explanation for the higher dosage plot having more infested fruit, unless possibly more run-off of spray occurs with the increased amount of wetting agent. The insecticide residue was much less evident on the fruit that were sprayed when compared to dusted fruit. However, the wettable powder formulations left a faint to easily observable ring around the lower end of the fruit, where the material dried, as compared with the emulsifiable con-

Table 2. Effect of various malathion dosages or formulations on the infestion of Khadrawy and Medjool date by Nitidulid beetles in 1963.

Malathion Treatment	Khadrawy % beetle infested fruit at 6 weeks	8 weeks[2]
6 lbs. 25 W	0	....
8 lbs. 25W	0	....
51.2 oz. 57 EC[1]	0.4	....
5% Dust	0	....
Untreated Check	4.0	....
	Medjool	
6 lbs. 25 W	2.0	5.5
8 lbs. 25W	3.2	10.0
51.2 oz. 57 EC	11.7	11.0
Untreated Check	20.0	30.2

[1]51.2 ouces of 57% malathion emulsifiable concentrate is at the rate of 2 pounds of actual toxicant or comparable to 8 pounds of 25% malathion wettable powder.
[2]Khadrawy plots were over-dusted with a 25% malathion dust prior to the 8-week counts.

Table 3. Three month laboratory stored paper—tested October 16, 1963. Five (5) beetles confined to each petri dish cage.

Paper Type & Replication	No. of live beetles and date 10-17	10-19	10-20	10-22
T-1, a	2	1	1	0
T-1, b	2	1	0	..
T-1, c	4	2	0	..
T-2, a	1	0	..	..
T-2, b	0	..	..	.
T-2, c	2	0	..	..
Check, a	5	5	4	4
Check, b	5	5	5	5
Check, c	5	5	5	5

Table 4. Three month weathered paper—tested October 24, 1963. Paper cut from high and low position on bunch covers. Five (5) beetles confined to each petri dish cage.

Paper Type Replication and Position		No. of live beetles and date 10-26	10-27	10-28	10-29	10-30	10-31
T-1, a)		5	3	0	..	..	..
T-1, b)	High	3	1	0	..	..	..
T-1, c)		4	0	..	..	..	..
T-1, d)		5	2	1	..	..	..
T-1, a)		3	1	0	..	..	..
T-1, b)	Low	4	1	0	..	..	..
T-1, c)		5	2	0	..	..	..
T-1, d)		4	1	0	..	..	..
T-2, a)		5	1	0	..	..	..
T-2, b)	High	5	2	0	..	..	..
T-2, c)		5	0	..	..	..	..
T-2, d)		5	2	0	..	..	..
T-2, a)		2	2	1	..	..	..
T-2, b)	Low	5	1	0	..	..	..
T-2, c)		4	2	0	..	..	..
T-2, d)		5	1	0	..	..	..
Check, a		5	5	5	5	4	4
Check, b		5	5	5	5	5	5
Check, c		5	5	5	5	5	5

centrate sprayed fruit which showed no evidence of residue remaining at harvest time.

More than one application of emulsifiable concentrate malathion might greatly reduce beetle infestations and at the same time eliminate the need for washing the fruit.

Preliminary tests were conducted to determine the effectiveness of lindane-impregnated paper date bunch covers in reducing infestations of nitidulid beetles in the fruit. Paper covers are regularly used to protect dates after the khalal stage of fruit growth, or when the color changes from green and the fruit has reached full size. Although nitidulid beetles generally fly into the open end of paper-covered bunches and probably do not come in contact with the paper, there might be some fuming or even repelling effects from properly released insecticides impregnated on the paper. It was the purpose of these tests to determine the feasibility of this idea by using paper supplied by the originators of such treated paper.

Two types of paper covers numbered typeI and type II were received July 20, 1963. One group of each type was kept in the laboratory at room temperature and another group of each type was placed over date bunches near Indio, California, on July 22, 1963. Labortary-reared nitidulid beetles were used in a bio-assay test to determine the longevity of toxic residues from these two groups of positioned paper covers. Samples of paper to be tested were cut into circles the same size as a petri dish. These paper discs were placed in the bottom of petri dishes and 5 beetles were confined along with a food supply (canned pumpkin). In each series of tests, untreated check petri dishes were also treated in the same manner by substituting filter paper for the treated paper. Periodic observations were made to determine the number of living or dead beetles.

Tables 3 and 4 give the results of the final tests made before the fruit was picked. Results obtained between July 22 and the final test have been omitted because of duplication.

After three months the paper which had been kept at room temperature killed all the beetles after three days of confinement in contact with the paper. The beetles confined in the untreated check petri dish cages survived this same period of time and were maintained for a week longer.

Just prior to harvest the paper samples from the field were selected both high and low on the bunch to determine any differences of weathering in these positions. Position on the bunch did not matter, as all replicated tests gave complete kill in four days of confinement.

These bio-assay tests show that impregnated paper covers after three months' exposure to the climatic conditions found in date gardens in the Coachella Valley of California were capable of killing nitidulid beetles on forced contact.

No conclusive results were obtained by field use of a large number of impregnated paper bunch covers. The lack of field data was primarily due to the scarcity of beetle-infested fruit in the date gardens selected for these tests.

LITERATURE CITED

Elmer, H. S. 1962. *Date pest control studies. Date Growers' Inst. Ann. Rept.* 39: 2 *and* 3.

RAIN DAMAGE TO DATES IN 1963

By Roy W. Nixon

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The 3.35 inches of rain recorded at the U. S. Date and Citrus Station during the critical August-October period of 1963 was the highest of any year since the all-time high[1] of 8.96 inches in 1939. In only one other year, 1945, was the rainfall more than 3 inches during this period. Records for the 3 years are compared in Table 1. In both 1939 and 1945 crop losses were close to 50 percent (1, 3), the highest in the history of the date industry. In 1963, on the other hand, the overall loss in marketable fruit is estimated at about 15 percent. This estimate is based on fruit harvested in relation to the crop forecast and on increase in culls, both in field and in packing houses. Losses varied greatly between different gardens, ranging from 30 to 50 percent in some and practically 100 percent in a few. In any event, however, the loss in 1963 was much less than might have been anticipated from losses in other comparable years. An analysis of the conditions in 1963 provides some explanation.

[1]*U.S. Weather Bureau data for Indio, California, recorded at the Southern Pacific Railroad station beginning in* 1878 *and at the U.S. Date and Citrus Station since* 1911.

Table 1. Years with more than 3 inches of rain during the critcial August-October period.

Month	1939		1945		1963	
	Rain (inches)	Days (number)	Rain (inches)	Days (number)	Rain (inches)	Days (number)
August	T	3	2.38	4	.12	1
September	8.96	9	.52	1	2.02	6
October	0	0	.21	3	1.21	3
Total	8.96	12	3.11	8	3.35	10

The distribution of rainfall was as follows: .12 inches August 7; .12 inches September 4-5; .02 inches September 13; 1.88 inches September 17-19; 1.21 inches October 17-19. The beginning of ripening was about 10 days later in 1963 than in 1962, which made it the latest season in several years.

Although the type and time of rain damage could be determined by observations during the season, reliable estimates of the amount of damage could not be made until after the harvest because of the height of most of the palms and the infrequency of picking. Most of the damage was associated with the heavy rain of September 17-19 and not until after that were close inspections of the fruit made. It was evident then that humidity in August and early September had contributed to the damage by producing checks and cracks in the fruit and favoring incipient rot.

Clear weather and light breezes followed the September 17-19 rain and by drying the fruit checked the increase of rot, but the rain of October 17-19 provided another period favorable for the development of rot and increased the damage to late-ripening fruit. In this connection, it has often been observed that fruit on tall palms 30 to 50 feet high, is less damaged by rain than fruit on small palms close to the soil. Conditions for aeration and drying are better at higher elevations.

Rain damage is nearly always accompanied by an increase in insect infestation. That there was relatively

little increase in insect infestation in 1963 is evidence of the effectiveness of malathion (6). During the last few years fruit in most date gardens has been dusted with a mixture of 4 percent malathion and 5 percent fermate (ferbam) in a carrier, half of which is sulfur and the remainder an inert material. Fermate was found by Bliss (1) and by Darley and Wilbur (2) to reduce fruit rot when applied to the bunches in advance of rain and humid weather. Applications of the malathion-fermate mixture had been made to a large percentage of the Deglet Noor gardens prior to the September 17-19 rain and were made again following that rain and before the October rain. Insects increase the amount of rot by spreading the causal fungi from infected to sound fruit.

The following comments on the behavior of the different commercial varieties are based on interviews with growers, packers, retailers, and on my own observations. The susceptibility of these varieties to different types of rain damage has been noted earlier (4, 5). When protected from rain the bunch is either covered with a paper tube tied to the fruit stalk above or with a wrap-around sheet of paper attached in the same way

Deglet Noor. During the last decade so little rain damage has occurred that some date growers have abandoned rain protection and about 10 percent of the Deglet Noor bunches were not covered. The maturity of Deglet Noor dates at the time of the rain of September 17-19 varied from about 20 percent ripe in the earliest gardens to just beginning to ripen in the latest gardens. Uncovered khalal fruit was badly damaged by the cracking and tearing resulting from contact with water; fruit rot and drop began to appear a few days later. Damage in these gardens was estimated at 30 to 50 percent or more. In most of the gardens where Deglet Noor dates were covered, rain damage was relatively slight, not more than about 10 percent, although there were some exceptions in which 25 or 30 percent of the covered fruit was lost, mostly as a result of rot and drop. As might be expected, wrap-around paper sheets were not as effective in rain protection as paper tubes, because some of the former, if not well secured, were loosened and partially blown off by wind, resulting in exposure of the bunch, so that in many gardens some of the fruit was damaged from contact with water.

In some of the better Deglet Noor gardens where dates were well protected, quality of marketable fruit was equally as good as in the previous year and the size was a little larger. In comparison with the 2 previous years, however, the overall quality of the crop was lowered by checking and blacknose, rain cracks, premature shrivel, and by harvesting some of the fruit when it was too wet.

Khadrawy. The fruit was about ¾ ripe when the rain of September 17-19 occurred and in most gardens one picking had already been made. Because it is early-ripening and has some degree of tolerance to occasional periods of high humidity, this variety is currently seldom proteced from rain. Direct rain damage to Khadrawy was relatively slight and loss, mostly from fruit drop, was estimated at 5 percent. However, the fruit was too wet when harvested and subsequently there was some trouble form fermentation. Aside from rain damage, Khadrawy quality, except in a few gardens, seemed to be below average this season.

Halawy. The fruit, which ripens at about the same time as Khadrawy, was damaged to about the same extent. Only a few bunches were covered. Tip-shrivel and dry-bases, which often show up in this variety, were seldom seen in 1963. The harvested fruit was even wetter than Khadrawy and darkened more after harvest.

Zahidi. When the rain of September 17-19 occurred, the fruit was about half ripe and was covered in about half of the date gardens. About 5 percent of the uncovered fruit developed pronounced cracks and a heavy drop followed. Covered fruit suffered little damage except for some loss from drop. Overall quality was not quite as good as in the previous year.

Medjool. The fruit was about 2/3 ripe September 17-19 and all covered. Little or no direct rain damage was observed but fruit did not cure very well. Size was a little smaller than the previous season, but quality was generally reckoned equally as good.

Barhee. Fruit was just beginning to ripen in the earliest gardens on September 17-19. Rain cracks developed earlier but most of the damage came from the October rains. In at least one garden the fruit was not covered and was a total loss. Covered fruit in other gardens suffered from failure to cure on the palm and from darkening and fermentation after harvest.

SUMMARY

Rains during the critical August-October ripening period reduced the 1963 date crop about 15 percent from cracking, rot and drop. The average grade of marketable fruit was lowered by checking, blacknose, broken skin, excessive moisture, darkening, and failure to ripen and cure properly on the palm. The damage was much less than in other years of comparable rainfall, which is probably explained by better weather for drying immediately following the first heavy rain, increased height of most palms, and the use of malathion-fermate dust which decreased insect infestation and the development of rot.

REFERENCES

1. *Bliss, D. E. 1946. The use of fungicides against spoilage in dates. Date Growers' Inst. Rpt.* 23: 13-17.
2. *Darley, E. F., and W. D. Wilbur. 1955. Results of experiments on control of fruit spoilage of Deglet Noor and Saidy dates in California, 1935 - 1954. Date Growers' Inst. Rpt. 32: 14-15.*
3. *Jenkins, W. G., et al. 1940. Rain damage to dates—discussion. Date Growers' Inst. Rpt. 17: 15-19.*
4. *Nixon, R. W. 1933. Notes on rain damage to varieties at the U. S. Experiment Date Garden. Date Growers' Inst. Rpt. 10: 13-14.*
5. *Nixon, R. W. 1942. Rain and high humidity tolerance of commercial date varieties. Date Growers' Inst. Rpt. 19: 12-13.*
6. *Vincent, L. E., and D. L. Lindgren. 1954. Malathion dust for control of nitidulid beetles and pyralid moths infesting Deglet Noor and Khadrawi dates in the Coachella Valley. Date Growers' Inst. Rpt. 31: 28.*

SAMPLING DATE PRODUCTS

Coffee, punch and delicious cakes were served at the close of the Institute meeting by members of the Laflin Date Gardens.

Starting in 1912 with a large variety planting of dates, and with help and advice given him by the United States Date Garden in Indio, Ben Laflin soon found many problems facing him in the marketing of his products. With the help of an imaginative family he now has developed his own market through expanding mail order, date shop and wholesale outlets.

EFFECTS OF HEAT PROCESSING ON THE PROPERTIES OF DATES[1]

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A large portion of dates packed in California undergo some form of heat treatment before they are marketed. Knowledge of the chemical and physical changes that take place in dates when they are heated and control of these changes are essentiol to the production of uniform, high-quality processed dates.

This paper provides an up-to-date summary of our research on the chemical and physical changes in dates during heat treatment and storage.

COLOR

The color of tree-ripe and heat-processed dates appears to be due primarily to brown pigments formed during maturation, processing, and storage (3). There is a broad range over which date color is considered acceptable, although extremes of lightness and darkness or off-colors such as greenish or reddish shades are undesirable. Also, lack of uniformity in color among dates in a single package or among different packages is not desirable.

Many systems are involved in brown pigment formation (5,6,8,9,10). Three different systems have been demonstrated in date tissue: sugar browning, enzymic oxidative browning of polyphenols, and oxidative browning of tannins (9). Although studies may show the presence of other systems, a general picture of browning of dates is now established.

In general, the known browning reactions in dates occur more rapidly at elevated temperatures than at refrigerator temperatures (6,11). Their relative rates, however, differ widely at a given temperature. At room temperature, for example, enzymic browning of polyphenols proceeds at observable rates, whereas sugar browning is much slower. However, above 100°F., sugar browning predominates over oxidative browning of polyphenols and tannins in whole Deglet Noor dates of 19 percent moisture (6).

Browning reactions are also slow at very low moisture levels (12). Very dry dates have been held at room temperature for years without appreciable darkening. The relative rates of the three browning systems as a function of moisture content are not known. However, with dates of 19 percent moisture the rates of sugar browning and oxidative browning of polyphenols and tannins are about equal at 83° F.

[1]*Work supported in part by the Date Administrative Committee, Indio, California.*

[2]*A Laboratory of the Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.*

Since the color of dates is primarily due to pigments produced by browning reactions, it is of interest to interpret the role played by each system during ripening, processing and storage. As the green date softens during ripening, the concentration of polyphenols, which undergo enzymic browning, decreases and the fruit becomes light-brown in color. However, as the season progresses and the fruit dries on the palm, the browning enzymes are probably inhibited by the low moisture content so that enzymic browning is slowed appreciably. Thus, dry fruit having a very light or slightly greenish color has probably dried to a low moisture content before sufficient enzymic browning could take place. After hydration and an intermediate storage period, the fruit has a medium-brown color, and the polyphenolic-enzymic-browning substrates are no longer detectable (9). Thus, it appears that enzymic browning of naturally occurring polyphenols is mainly responsible for the brown color of ripe dates and also contributes somewhat to browning during processing and early storage. It does not appear to be responsible for the very dark color of dates stored a long time.

Because of their slow rates at normal temperatures, tannin browning and sugar browning appear to be of greatest importance during heat processing and storage following processing. Their increased importance after processing is probably due to the formation of brown-pigment precursors during heating which readily lead to brown pigments during subsequent storage.

Many details of chemistry of sugar browning are known from studies with model systems (1,2), but very little is yet known about the chemistry of tannin browning. Oxygen and the insoluble tannins are involved (9), but full details of the chemical structures of the tannins are not known. Whether the tannins themselves, or breakdown products of the tannins, are the actual reactants remains to be determined.

When Deglet Noor dates are heated to temperatures above 140° F., a reddish color develops and astringency and off-flavors are detected. The origin of these undesirable red pigments and astringent compounds is not known, but it is possible that they arise as breakdown products of the insoluble leucoanthocyanidin tannins. Heating date leucoanthocyanidin tannins in the presence of strong acids results in the formation of red anthocyanidin pigments. Whether this reaction or similar reactions occur when dates are heated remains to be determined. Some of the off-flavors are probably a result of sugar browning which is promoted by high temperatures.

The main enzymic browning substrates in dates are the dactylifric acids which, in chemical terms, are the three isomeric monocaffeoylshikimic acids, all newly discovered compounds that are apparently not found in other common fruits (7). Numerous flavans also occur in small amounts in dates and all are enzymic browning substrates.

It is clear that in order to pack dates of pleasing and uniform color all of the browning reactions must be considered. Since color is most easily developed during heat processing, this step affords the best opportunity to achieve color uniformity. However, improperly conducted heat processing, particularly the use of excessivley high temperatures, can be detrimental. Because the color is most stable in dry dates, field-dry fruit is best for storage. Once the fruit is hydrated, color begins to darken, and fruit stored for different periods differs in color. On the other hand, the small color variations of fruit stored in the dry state can be largely equalized by controlled heat processing.

High quality dates, which usually require little or no hydration, frequently have a greenish-cast and color variability which detract somewhat from their appearance. These dates can be improved by a short heat treatment at about 120° F. Reddish off-colors, when they occur, are generally encountered in dry dates that required long hydration and processing periods. These off-colors can be prevented by avoiding temperatures in excess of 140° F.

TEXTURE

One of the most important and useful changes that can be brought about by heat processing is improved texture. Consumers generally prefer dates that have a smooth, tender texture as opposed to those having an uneven, tough, fibrous or rubbery texture. The reason some Deglet Noor dates tree-ripen to a relatively tender texture while others do not is unknown, but it appears to be related to the amount of invert sugar present. Both toughness and low invert sugar content are probably caused by limited natural enzyme action during ripening, perhaps due to low moisture content. If the fruit dries on the palm before sufficient enzyme action has taken place, the dates will be tough and have a low invert sugar content. Fortunately, the enzymes are not destroyed as the fruit dries, they are only dormant and can be reactivated by raising the moisture content and temperature of the fruit. Generally, the heat applied to dry dates during

the time it takes to steam hydrate them to the optimum 23-26 percent moisture is not sufficient to improve their texture to the most desirable level.

This problem of obtaining sufficient sucrose inversion and tenderization in a practical time period was solved several years ago with the development of the inversion process (4). In this process, dates are hydrated to a moisture content higher than that at which they are to be packed, and then they are allowed to dry down to the finished moisture content during a holding period at elevated temperatures. This procedure makes use of the greater speed of sucrose inversion (formation of invert sugar) and tenderization at high moisture levels and elevated temperatures, and permits tenderization in commercially practical time periods. For example, sucrose inversion is 5.1 times faster at 140° F. in dates of 30 percent moisture than in those of 20 percent moisture, and it is 6.3 times faster at 140° F. than at 100° F. (with dates containing 31 percent moisture).

The effect of the inversion treatment on the texture of dates is illustrated by the data in Table 1. Hydrated, uninverted dates (34 percent invert sugar) are compared with similar dates that have been treated by the inversion process (65 percent invert sugar). Inverted dates have a much more tender texture than untreated dates at all moisture levels.

During the inversion process, the chemical change of greatest magnitude is the conversion (hydrolysis) of sucrose to invert sugar. Generally, tough dates have invert sugar contents of 25-35 percent (dry weight basis), whereas tender dates have invert sugar contents above that. However, the pectic substance and cellulose fibers in fruits are generally responsible for toughness and fibrousness, and the breakdown of these materials probably contributes significantly to the improvement in tenderness. A great deal remains to be learned about the many chemical and enzymic reactions and physical changes which take place during the inversion process.

CONCLUSIONS

Heat processing coupled with moisture control can be used to improve the color, texture and general quality of Deglet Noor dates, but attempts to accelerate the process by use of temperatures in excess of 140° F. may result in the development of off-flavors, off-colors, and astringency. Very short processing times may leave the fruit with inadequate color and coarse texture, whereas excessively long times cause off-flavors and dark color. The time, temperature, and moisture requirements for the development of optimum color, texture, and general quality are not necessarily the same for all grades and lots of fruit.

LITERATURE CITED

1. *Burton, H. S., and McWeeny, D. J. 1964. Non-Enzymatic Browning: Routes to the Production of Melanoidins from Aldoses and Amino-Compounds. Chem. and Ind.: 462-463.*
2. *Hodge, J. E. 1953. Dehydrated Foods. Chemistry of Browning Reactions in Model Systems. J. Agr. Food Chem. 1: 928-943.*
3. *Maier, V. P. and Schiller, F. H. 1960. Studies on Domestic Dates. I. Methods for Evaluating Darkening. Food Technol. 14: 139-142.*
4. *Maier, V. P. and Metzler, D. M. 1961. Sucrose Inversion in Deglet Noor Dates and its Processing Applications. Date Growers' Institute Ann. Rpt. 38: 5-8.*
5. *Maier, V. P. and Schiller, F. H. 1961. Studies on Domestic Dates. II. Some Chemical Changes Associated with Deterioration. Jour. Food Sci. 26: 322-328.*
6. *Maier, V. P. and Schiller, F. M. 1961. Studies on Domestic Dates. III. Effect of Temperature on Some Chemical Changes Associated with Deterioration. Jour. Food Sci. 26: 529-534.*
7. *Maier, V. P. 1963. Hydroxycinnamoyl Esters of Quinic and Shikimic Acids. In Aspects of Plant Phenolic Chemistry, Edited by V. C. Runeckles, Proc. Third Ann. Symp. of Plant Phenolics Group of North America, Toronto, Canada: 53-67.*
8. *Maier, V. P., Metzler, D. M. and Huber, A. H. 1964. 3-0-Caffeoylshikimic Acid (Dactylifric Acid) and its Isomers, a New Class of Enzymic Browning Substrates. Biochem. Biophys. Research Comm. 14: 124-128.*
9. *Maier, V. P. and Metzler, D. M. In press. Quantitative Changes in Date Polyphenols and their Relation to Browning. Jour. Food Sci.*
10. *Rinderknecht, H. 1959. The Free Amino Acid Pattern of Dates in Relation to Their Darkening During Maturation and Storage. Food Research 24: 298-304.*
11. *Rygg, G. L. 1956. Effect of Temperature and Moisture Content on the Rate of Deterioration in Deglet Noor Dates. Date Growers' Institute Ann. Rpt. 33: 8-11.*
12. *Rygg, G. L. 1957. The Relation of Moisture Content to Rate of Darkening in Deglet Noor Date. Date Growers' Institute. Ann. Report. 34: 12-13.*

Table 1. Effect of inversion treatment on the firmness of dates of different moisture contents.

Moisture content	Firmness of dates	
	Untreated	Inverted
(percent)	(sq. in./mg.)*	
15	51.7	39.0
20	32.4	18.4
25	25.4	13.5
30	21.4	12.0
35	19.5	11.3

*Area under force-distance curves (recording shear-press) per milligram dry sample. High values=firm dates, low values=tender dates.

ROOT-KNOT NEMATODE DAMAGE TO DATE PALM SEEDLINGS IN RELATION TO GERMINATION AND STAGE OF DEVELOPMENT

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INTRODUCTION

Root-knot nematodes have not been studied as parasites of date palms (*Phoenix dactylifera L.*), although their accurrence on palm roots has been known for 40 years. R. W. Nixon told me that he accompanied G. Thorne on a brief survey of date orchards in the Coachella Valley in June, 1925, and evidence of root-knot damage was found. Thorne's report on the survey has not been located, but Tyler's ((11) remarks undoubtedly refer to it and are quoted in full: "THORNE, G. (Division of Nematology, Bureau of Plant Industry. 1938): Many young palms appeared to be retarded in growth by heavy infestation when visited in 1925; by 1938 these plantings had apparently largely recovered and were growing normally. California."

Meanwhile, Buhrer *et al* (1) and Hollis (2) reported root-knot nematodes on date palms. R. C. Baines and S. A. Sher have told me that nematodes are found commonly on date palms in the Coachella Valley. Authors after 1950 identify the root-knot nematodes on date palms as *Meloidogyne* sp., except Jensen (4), who reported *M. incognita* (Kofoid and White, 1919) Chitwood, 1959, on date palms in nurseries in the western United States.

The work reported here was begun in June, 1963, after a breeding and selection plot of date seedlings was found heavily infested and damaged, apparently by root-knot nematodes.

GERMINATION and SEEDLING DEVELOPMENT

The stage of development of the date palm seedling at the time of infection by root-knot nematodes is of paramount importance in determining first, whether the seedling will emerge above ground, and second, whether it will continue to grow. Date seeds have unique characters and requirements that affect their use in experimental work; therefore, the features of date seeds, date seed germination and seedling development related to the nematode studies that follow are discussed.

[1]*I wish to thank J. R. Furr and R. W. Nixon of this Station for proposing and assisting with this study, and, at the University of California, Riverside, to thank R. C. Baines, A. Bell, and S. A. Sher for assistance with the nematological work and K. L. Middleham for the photography. Grateful acknowledgment is made to Oxford University Press, Inc., for permission to reproduce Figure. 1.*

The date palm is dioecious and heterozygous. Its seeds produce equal numbers of male and female plants which are all genetically different from each other but often tend to resemble the female parent in vegetative characters. Thus, in experimental work enough seedlings must be used to compensate for variability.

In exploratory trials freshly-extracted date palm seeds germinated readily and did not require after-ripening. Hot-water treatments suggested by Molisch (5) for palm seeds did not increase the percentage of germination or hasten it. Both pre-soaked seeds and those planted directly in moist sandy soil at 25 to 30° C. imbibed water equal to about 25% of their dry weight within 3 days and began to germinate in about 1 week.

The morphology of date seed germination (Fig. 1) was described by Sachs (9, 10) and his accounts are combined with recent observations on rate of development under optimal conditions. The cotyledon is composed of 2 distinct parts. One, corresponding to the leaf blade, remains within the seed as a bladder-like absorbing organ and gradually expands as the endosperm is absorbed. The other part emerges from the seed through a centrally-located pore opposite the furrow as a strongly geotropic, tubular, cotyledonary sheath that carries the rest of the embryo down several centimeters into the growing medium. When about 2 weeks old, the cotyledonary sheath is fully elongated and the point grows into a strong, primary root that develops secondary branches within a few days. All subsequent roots are adventitious and arise from the base of the stem. The sharp-tipped plumule grows upward, pierces the cotyledonary sheath, and emerges 3 to 4 weeks after planting, to develop the first true leaf encased in a sheath leaf. The first 4 to 6 leaves of vigorous plants are unifoliate; subsequent leaves begin to assume the adult pinnate condition with thorns on the basal margins of the rachis. Seedlings produce 1 new adventitious root for each leaf during at least the first year of growth. Numerous observations indicate that the seed contains enough stored food to develop and sustain the first true leaf for a few weeks even though the root system is virtually destroyed.

METHODS AND MATERIALS

General. These studies were made in glasshouses where air temperatures ranged from 14 to 40° C. Soil temperatures are given elsewhere. Two soils were used: (a) control soil, a fine dune sand with low silt content and free of root-knot nematodes, and (b) infested soil, a fine dune sand with moderate silt content from a planting of 'Deglet Noor' palms infested with root-knot nematodes. When non-infested, both soils were suitable for good growth of palm seedlings. Steam sterilized control soil was used for pathogenicity studies.

Date roots were damaged by contact with metal cans so that when feasible plastic or clay pots were used. However, heavily-asphalted 5-gallon metal cans were used for prolonged growth studies and root damage was negligible. Sample plants were washed free of soil and debris, blotted dry, and weighed immediately. Tops and roots of each plant, except as noted, were weighed separately. Height of top was measured from the root collar to the tip of the longest leaf. Varietal names are spelled according to the usage of Nixon (6), and legitimate names are distinguished by single quotation marks (3).

Pathogenicity.—'Deglet Noor' date seedlings were raised in sterilized control soil. Two seeds were planted vertically in a total of 100 planting bands placed on small clay pots (Fig. 2A). In the inoculated series, when the seedlings emerged, the band was removed and the sand washed away to expose the root collar. A mass of clean, washed root-knot nematode eggs was placed alongside the root collar, covered with sterilized sand, and immediately watered. The pot was plunged into a flat of new vermiculite which covered the seedlings to their original depth. Control plants were grown under comparable conditions. Soil temperatures ranged from 20 to 25° C.

Natural infection.—'Deglet Noor' date seeds were planted 7 per can in 2 series of 120 1-gallon cans; 1 series contained infested soil and the other control soil. 'Early Pak No. 7' tomato seeds were planted with the date seeds in both series to increase the nematode population. The tops of the tomato plants were removed when the date seedlings emerged. The germination rate of date seeds was about 90%, but because of shallow planting 5% of the seeds were pushed above ground during germination and died. Percentage of emergence of seedlings was determined at intervals of several weeks in 25 cans selected at random from each series. Soil temperatures ranged from 23 to 30° C. during the first 4 months of this experiment and thereafter were a few degrees lower.

Growth.—Twenty cans each containing 5 10-week-old plants with good

tops, were selected from the control soil and infested soil series described under "Natural infection". This procedure favored the plants in infested soil, as less than one-third of the cans had 5 good plants while most of the control cans did. Soil and plants were transferred to 5-gallon cans containing control soil in both series. Five cans of each series (25 plants) were harvested at intervals for growth measurements. Soil temperatures ranged from 20 to 30° C. from August through November, 15 to 30° C. through December, and 14 to 29° C. thereafter through March.

Varietal tolerance.—Seedlings of 8 date palms varieties were grown in 1-gallon cans in soil free of root-knot nematodes. The plants and soil of 2 cans of each variety were transplanted into 2 2-gallon cans containing control soil in 1 series and infested soil in the other. The total number of plants (6 to 10) per variety in each series was uniform. The eight-month-old plants were healthy, though somewhat pot-bound in the original containers. At harvest, the tops were weighed individually but roots were weighed on a pot basis. Soil temperatures ranged from 20 to 30° C.

A second tolerance trial was made with seedlings of 50 date varieties. 'Early Pak No. 7' tomato plants were grown from seed in all pots for 6 weeks and then clipped near soil level before planting the date seeds which were harvested from the 1963 crop. Fifty seeds, except at noted, of each variety were sown in 5 pots (10 seeds per pot) of each soil. The pots were plunged in vermiculite in heated beds and kept at 25 to 30° C. for 2 months, and at 23 to 28° C. thereafter. When seedlings began to appear in the control series, frequent counts of emergence were made. Within 2 weeks emergence was obviously very poor in the infested soil and germination had to be verified. The rate of germination was determined by removing the seeds from 1 can of each variety in the infested-soil series.

RESULTS

Causal nematode and symptoms.—The root-knot nematodes concerned in these studies were identified as *Meloidogyne javanica* (Treub, 1885) Chitwood, 1949, through the kindness of R. C. Baines. This species predominated, although others might have been present in the naturally-infested soil. All underground portions of seedlings were attacked, including the cotyledonary sheath, young leaf bases, root collar, and especially roots. (Fig. 2 D, E. F. G.). Secondary damage was caused by fungi and perhaps other microorganisms, but the extent of this was not determined. Date palms showed a remarkable capacity for quick and abundant root regeneration (7) (Fig. 2C) even from roots that were extensively galled and rotted. Compared with normal seedlings, infected plants showed varying degrees of stunting accompanied by paler leaf color and slower development of adult leaf characters.

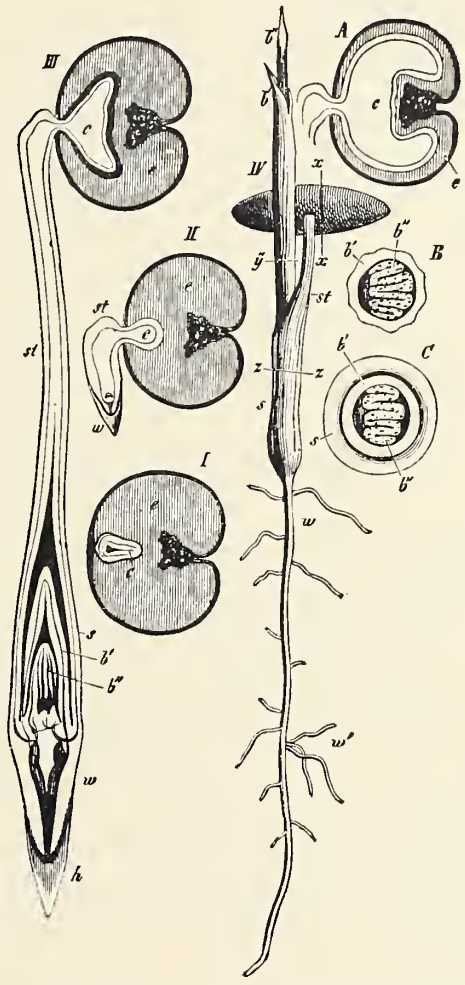

FIG. 236.—Germination of *Phœnix dactylifera*. *I* transverse section of the resting seed; *II, III, IV* stages in the germination (*IV* nat. size); *A* transverse section of the seed *IV* at *xx*; *B* transverse section of *IV* at *xy*; *C* ditto at *zz*; *e* the horny endosperm; *s* sheath of cotyledon; *st* its petiole; *g* its apex, developed into an absorbing organ which gradually exhausts the endosperm, and at length replaces it; *w* the primary root; *w'* lateral roots; *b'b''* the leaves which succeed the cotyledon, *b''* becomes the first foliage leaf; in *B* and *C* its folded lamina is seen in transverse section.

Fig. 1. Germination of the date palm seed, after Sachs (10), 1887. Reproduced by permission of the Oxford University Press, Inc.

Pathogenicity. — M. javanica was pathogenic on 1-month-old date seedlings grown in sterilized soil. Ten weeks after inoculation roots of 57 control plants were healthy, whereas 35 of 36 inoculated plants had varying degrees of nematode injury; 1 plant was not infected. An average of 11 root-knot galls per plant occurred on the first 10 cm of primary root with its secondary branches (Fig. 2B). The first adventitious root was just emerging on many seedlings and was not visibly infected. In addition to galls on the roots, one-third of the plants had infections on the cotyledonary sheath and a few galls at the root collar. Discoloration was slight on the infected tissues suggesting that microorganisms carried on unsterilized, washed egg masses were a negligible factor in the initial damage caused by nematodes. Inoculated plants had fewer secondary roots than the controls, but infected roots were thicker than normal ones; plants of both series were about equal in weight and height.

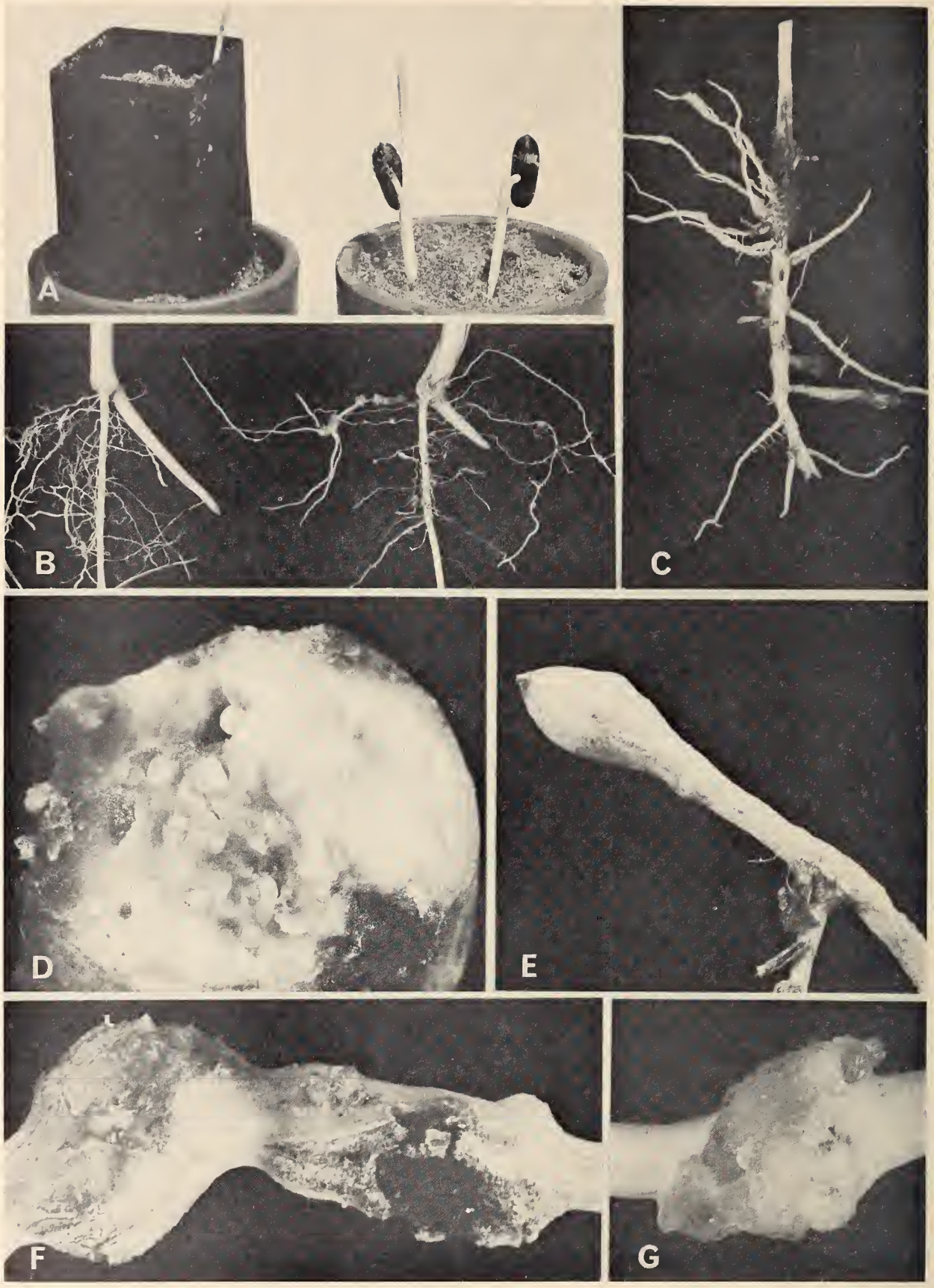

Fig. 2. A) Method of growing date palm seedlings to be inoculated with root-knot nematodes. Root collar is exposed by washing without disturbing the roots; 1 month old (X 0.5) B) Left, healthy roots; right, roots inoculated with *M. Javinica*, 10 weeks after inoculation (X 1). C) Root regeneration from a severely infected root (X 0.5). D to G) Root-knot nematode damage on small roots; secondary invasion of microorganisms indicated by darkened tissues all (X 10). D) Terminal gall with approximately 25 female nematodes visible. E) Terminal and auxiliary galls. F) Intercalary galls, with egg masses. G) Characteristic secretion of gelatinous material about egg masses on young active galls.

Natural infection. — Emergence of seedlings from control soil was 85% at 10 weeks after planting and less than 1% of the plants died. Emergence was 70% from infested soil and at 19 weeks 26% of the emerged seedlings had died, leaving a net survival of 44%. Most of the survivors were stunted and unthrifty.

Growth.—The size of average control and infected 'Deglet Noor' date seedlings 42-weeks old is compared in Fig. 3A. Control plants weighed 85 g, were 58 cm high, had 7.0 leaves and 6.3 adventitious roots. Infected planteds weighed 35 g, were 35 cm high, had 5.8 leaves and 5.5 adventitious roots. Although infected plants had fewer adventitious and secondary roots than control plants, the galled roots were thickened. As a result, at the 26-, 36-, and 42-week intervals the roots of inoculated plants averaged 43 to 46% of the total plant weight; on control plants the roots averaged 29 to 31% of the total weight. Terminal leaves had become pinnate on 50% of the control plants, but on only 20% of the infected ones. During the experiment, 11% of the infected plants died. Root-knot nematodes migrated with the roots and were found in all parts of the containers. Although soil temperatures dropped to 14° C. on a few winter nights, growth of seedlings was good and nematodes remained active throughout the experiment.

Varietal tolerance. — Seedlings of 'Barhee', 'Deglet Beida', 'Deglet Noor', 'Halawy', 'Khadrawy', 'Medjool', 'Saidy', and 'Zahidi' date palms, that had an average weight of 17 g, were transplanted into control and infested soil, respectively. A total of 61 plants (8 varieties) were grown in each soil. Nineteen weeks after transplanting the average weight of seedlings was 61 g in control soil and 44 g in infested soil. Growth of all varieties was affected by the nematodes and plant weights were reduced 16 to 36%.

Seedlings of 50 date varieties were used in a second test of varietal tolerance to root-knot nematode infection, Table 1. Germination averaged 91% in the control and infected soils. Two months after planting, average emergence was 91% for seedlings in control soil and the plants continued to grow vigorously without losses (Fig. 3B). In contrast, at 2 months average emergence was 9% in the infested soil; at 5 months the survivors were reduced to 3%of the total seed planted and most plants were stunted. The importance and constancy of varietal differences in percentages of seedlings that survived is not known.

The large nematode population and favorable soil temperaures in the infested soil fostered such early and drastic infection of emerging seedlings that cotyledonary sheaths were infected and destroyed before the growing point developed (Fig 3B). Seedlings that did emerge usually had sparse roots of normal origin or developed a few small roots from a large gall at the base of the stem. The number of survivors decreased steadily

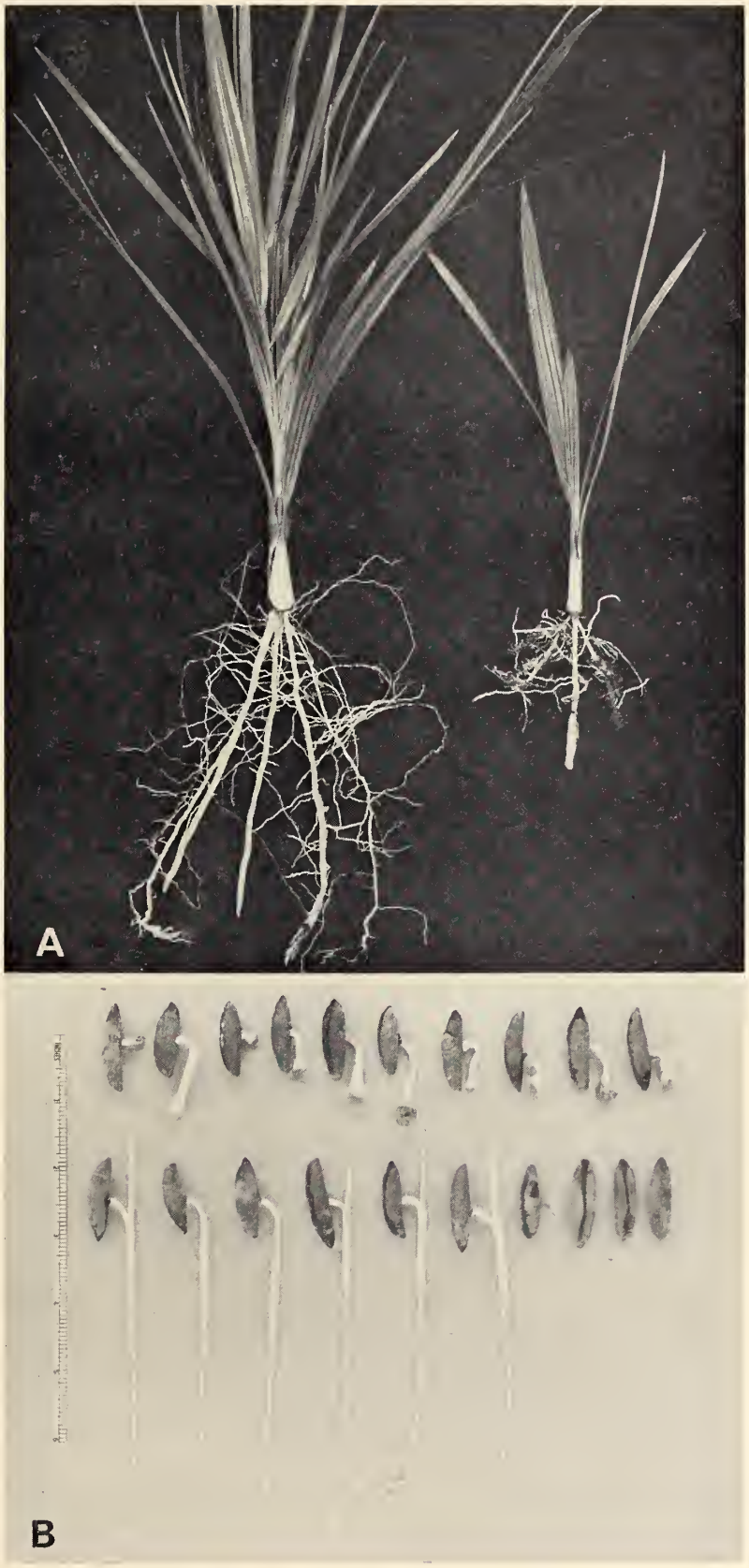

Fig. 3 A) Average specimens of 42-week-old 'Deglet Noor' date palm seedlings, based on weight and height. Left, control; right, infected with root-knot nematodes (X 0.16). B) Germination after 1 month of 'Deglet Noor' date palm seeds in representative pots of (Top) soil heavily infested with root-knot nematodes and (Bottom) non-infested control soil (X 0.5).

Three of the Moroccan varieties tested — 'Bou Zeggar de Beurda', 'Outoukdim', and 'Takerboucht' — are considered tolerant to the devastating bayoud disease (8) caused by *Fusarium oxysporum* Schlecht. var. *albedinis* (Killian & Maire) Malencon. Seeds of these varieties were obtained through the kindness of J. Louvet, Station de Pathologie Vegetale, Versailles, France.

DISCUSSION AND SUMMARY

Root-knot nematodes of the species *M. javanica* can infect and severely damage date palm seedlings. The most severe damage occurs when the growing point of the cotyledonary sheath is infected and killed before elongation is completed. Once a seedling in infested soil has a root and plumule its subsequent growth and survival depend mostly upon the severity of recurrent infections. Infected roots have a remarkable capacity for rapid regeneration of new roots. Roots of healthy seedlings several months old are readily infected when put in contact with infested soil and evidence of depressed growth soon appears. The role of fungi and other secondary organisms in root damage is unkown but appears to be important. Differences in growth between seedlings in non-infested and infested soils were striking at 10 months of age, even though the experimental conditions had favored the infected plants by forcing selection of the least damaged ones for continued study. Infection of seedlings of 50 varieties of dates revealed that most were severely damaged by root-knot nematodes. However, the survival of 10 to 20% of the seedlings in 8 varieties suggests that some populations might be useful in selecting and breeding date palms that combine tolerance to root-knot nematode injury with good horticultural characters.

LITERATURE CITED

1. *Buhrer, E. M., C. Cooper, and G. Steiner. 1933. A list of plants attacked by the root knot nematode (Heterodera marioni). Plant Dis. Rptr. 17: 64-96.*
2. *Hollis, J. P. 1962. A survey of plant parasitic nematodes and their control in Kenya. FAO Plant Protect. Bull. 10: 97-100.*
3. *International commission for the nomenclature of cultivated plants of the international union of biological sciences. 1961. International code of nomenclature for cultivated plants. 30 p. Edited by the editorial committee of the commission. Utrecht, The Netherlands.*
4. *Jensen, H. J. 1961. The nematode menace. Amer. Nurseryman 114 (8): 7-8, 105-113.*
5. *Molisch, H. 1922. Pflanzenphysiologie als theorie der gartnerei. 337 p. 5th Ed. Verlag von Gustav Fischer, Jena.*
6. *Nixon, R. W. 1950. Imported varieties of dates in the United States. 144 p. U. S. Dept. Agr. Circ. 834.*
7. *Peebles, R. H. 1936. Regeneration of date palm roots. Proc. Amer. Soc. Hort. Sci. 33: 376.*
8. *Pereau-Leroy, P. 1958. Le palmier dattier au Maroc. 142 p. Royaume du Maroc, Ministere de l'agriculture; Institut Francais de Recherches Fruitieres Outre-Mer.*
9. *Sachs. J. Von. 1862. Zur keimungsgeschichte der dattel. Bot. Zeit. 20: 241-246, 249-252.*
10. *Sachs, J. Von. 1887. Lectures on the physiology of plants. 836 p. Translated by H. Marshall Ward. Oxford, Clarendon Press.*
11. *Tyler, J. 1941. Plants reported resistant or tolerant to root knot nematode infestation. 91 p. U. S. Dept. Agr. Misc. Publ. 406.*

Table 1. Influence of a heavy infestation of root-knot nematodes on emergence and survival of date palm seedlings at 2 and 5 months after planting.[1]

Variety	Control soil	Infested soil	
	Emergence at 2 months %	Emergence at 2 months %	Survival at[2] 5 months %
Amber Queen	90	6	2
'Amhat'	98	14	4
'Amir Hajj'	100	4	0
'Badrayah'	98	14	12
'Bahrab'	82	6	0
'Barhee'	94	0	0
'Bou Zeggar de Beurda'[3]	100	30	20
'Braim'	76	6	0
'Dayri'	96	14	8
'Deglet Beida'	90	22	14
'Deglet Noor'	96	14	2
Desert Queen	90	24	18
'Gantar'	92	4	0
'Halawy'	94	6	4
'Hayany'[3]	92	3	0
'Hilali'	70	12	6
Honey	94	6	0
'Iteema'	96	12	6
'Jafari'[3]	100	31	16
'Jauzi'	90	4	0
'Khadrawy'	94	18	4
'Khalasa'	94	10	8
'Kustawy'	94	8	0
'Maktoom'	90	20	10
'Medjool'	94	2	0
'Menakher'	88	2	0
Outoukdim[3]	100	0	0
'Rhars'	84	16	6
Rhazee	90	10	2
'Sayer'	88	6	4
'Shukkar'	88	14	10
'Takerboucht'[3]	90	15	20
'Tazizoot'	86	4	4
'Thoory'	88	2	0
'Zahidi'	96	2	2

[1]50 varieties were used in this test, but 15 varieties were of uncertain origin and had low survival so they are not included.

[2]Percentage of total seeds planted

[3]Varieties with less than 50 seeds in each soil series were: 'Bou Zeggar de Beurda', 10; 'Hayany', 36; 'Jafari', 26; Outoukdim, 10; and 'Takerboucht', 20.

SECOND REPORT ON THE BENDING OF TOPS OF BARHEE DATE PALMS

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INTRODUCTION

In 1960 (5), an unusual disorder of Barhee date palms was reported wherein the tops of the palms were bent in a southerly direction. Observations on these palms at the former Russell-Alexander Ranch near Indio were made over a 2-year period. The malady did not involve any infection in the bud nor was there any evidence of black scorch disease caused by the fungus, *Thielaviopsis paradoxa*. Affected palms showed no apparent decrease in fruiting or in fruit quality. Nixon has observed the bending head disease in the Old World, and from a comparison of these two disorders believes that they are dissimilar.

Since the original description (5), of bending in Barhee palms, this disorder has been found in most of the older bearing plantings of this variety. All Barhee date palms in the Coachella Valley have been derived from a single lot of offshoots imported in 1913 from Iraq.

5. Darley et al. 1960 An unusal disorder of Barhee date palms. Date Growers' Inst. Ann. Rpt.. 37: 10-11.

OBSERVATION AND RESULTS

The observations begun at the Russell-Alexander Ranch in 1958 were augmented in 1960 and continued through 1963. A summary of 6 years' observations are reported here.

Observations were made in 2 plantings; one of 5 acres of palms 10 to 33 years old and the other a single row of 50-year-old palms grown from the imported offshoots. The criteria for observing the progress of the disorder are the same as those previously reported; namely, the height of the trees, the degree of bending above the bud area, the direction of the bending and the number of fruit bunches per palm.

The average yearly per cent of palms showing bending in the 5-acre planting (Fig. 1) indicates that the severity and incidence of bending increased through 1962. In 1963 the per cent of trees with 30°-90° class of bending decreased to only 2.5%, the lowest incidence observed during the 6 years. This was in marked contrast to percentages of 13 to 14.5% in 1961 and 1962.

In the 5-acre planting, the larger palms (Fig. 2) carried more fruit bunches regardless of bend but the number of fruiting bunches was reduced in all palms in direct relation to severity of bend. By 1963, 70% of the 391 palms in the 5-acre planting were more than 20 ft. in height. The direction of bend continues to be principally in a southerly direction with 80% of the palms in this category.

Four per cent of the palms 10-20 ft. high had severe bending and among palms more than 20 ft. high the incidence amounted to more than 20% in each of the 4 years from 1960 to 1963.

In the first report, one of the Barhee palms in the single row planting appeared to improved following the removal of most of the leaves around the shoot apex. Therefore, all of the palms in that row were pruned the following year and in 1964 showed marked improvement. To further investigate pruning as a possible corrective measure, 6 palms showing bending in excess of 30° were selected in the 5-acre planting in 1960 for treatment. A comparable group of 6 palms were left as controls. No definite effect of pruning was observed by 1963 as both pruned and unpruned palms straightened themselves.

The reason for the bending of Barhee palms is still not known, and is reported as an interesting phenomenon which should be observed through the succeeding years.

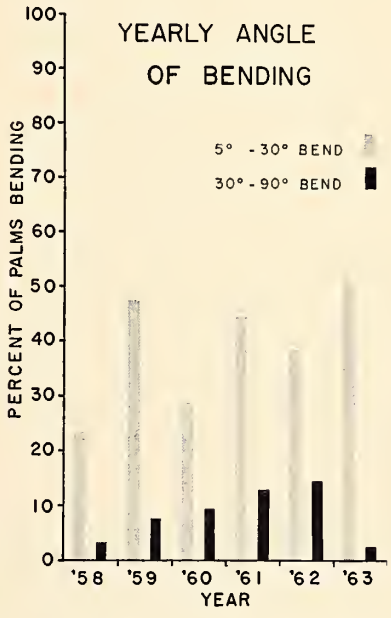

Fig. 1. Yearly angle of bending of Barhee date palms, expressed as mild (5-30°) and severe (30-90°) bending.

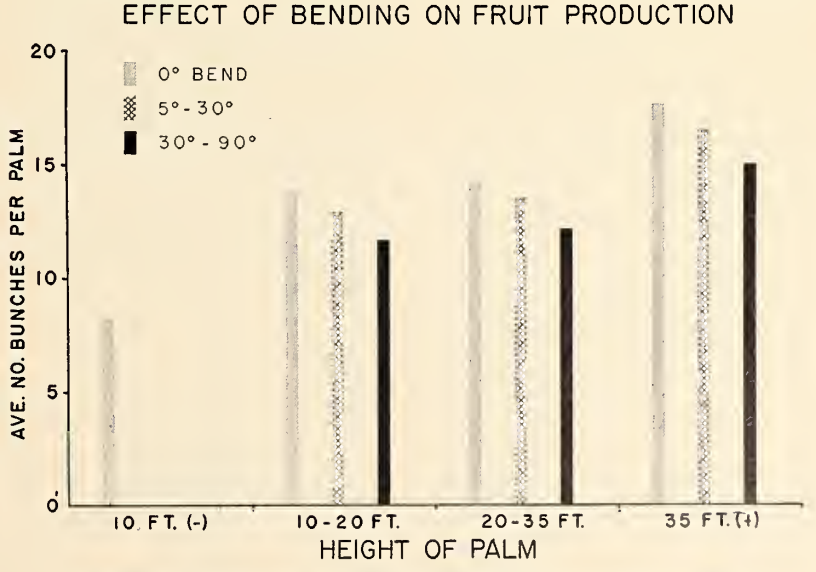

Fig. 2. Effect of bending on fruit production by Barhee date palms of various heights as indicated by numbers of bunches per palm. The graphs represent averages for 4 years, except for trees 35 ft. or taller, on which data first became available in 1963.

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DATE PROTECTION FROM INJURY CAUSED BY THE APACHE CICADA

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During the summer months in the desert regions of the Southwestern United States, large numbers of the adult Apache cidada, *Diceroprocta apache* (Davis) are present. They are usually not injurious to the date but are often injurious to certain other crops particularly asparagus (Stickney *et al.* 1950). However, during 1961 in one date-growing area near Indio, California, a loss in date crop tonnage was directly caused by the egg-laying habits of the Apache cicada. In this area a considerable acreage of asparagus was badly infested with cicada larvae.

The life history and biology of this insect has been determined on asparagus by Anderson and Shorey[1], but additional information was needed in relation to dates so that crop losses could be minimized.

The purpose of this discussion is to present the results obtained from the study of this cicada in date gardens, and the control methods that have been initiated.

Type of Injury

The immature stages feed on the roots of the date palms and may lower the vitality of the tree, but of most concern to the date growers is the loss of date fruit caused by the Apache cicada females' laying their eggs in the date strands. This habit, under certain conditions, causes the fruit to shrivel, dry up and fall to the ground. They lay their eggs also in the date leaves, but do not seem to prefer leaves to strands.

Habits

Observations were made in many date gardens in 1962 and data were taken from selected Deglet Noor date gardens where a considerable reduction in fruit yield resulted from cicada injury in 1961. Large numbers of flying adults were observed in these gardens by mid-July and the first punctures on date strands were found July 24.

The female punctures the strands and inserts her ovipositor, laying from 5 to 9 eggs per puncture, with an average of 7.1 eggs per puncture in 50 strands examined. These separate punctures are made in vertical rows as the insect moves upward between the first fruit and the base of the strand. No punctures were found on the strand between fruit. The rows were from a fraction of an inch long, with a single puncture, to 12 inches long with 53 separate punctures in one strand. When date bunches and strands were completely exposed to these adults, a single female usually made all the punctures on a single strand. However, when all the bunches on a tree except one were covered with paper bags and there was no choice of egg-laying sites except the one bunch or other parts of the palm tree, many of the strands on the exposed bunch had four to five separate rows of punctures. On all strands with two or more separate puncture rows, all the fruit subsequently shriveled and dried up. Shriveled fruits were found only occassionally on strands having a single row of punctures. These strands had a smaller diameter than average or the female moved around the strand as she deposited her eggs, rather than in a vertical straight line.

Control

Chemical control of the Apache cicada in date gardens was initially considered because of the relative success with certain insecticides in the control of this pest on other crops. However, since only a few date gardens each year have been injured by this insect and chemical residue studies for registration on this crop are lengthy and expensive, control methods other than chemical were sought. A type of cover was first considered to prevent these insects from laying eggs in the date strands.

During these 2 years that this cicada has been injurious to dates, most of the egg laying has occurred at the time of year when it is a practice of date growers to cover date fruit bunches with paper for protection against injury by rain, birds, and insects other than the Apache cicada. The growers prefer to put these paper covers over the date bunches after the dates start to change color from green to brown as they ripen. If they are placed over the bunches too early, checking and "sunburning" occurs from the intense heat under the cover even though these cylindrical paper bag covers are left open at the bottom (Bliss *et al.* 1950).

Four single tree plots on each of three Deglet Noor date gardens were selected to test various types of bunch covers. Although paper-bag covers are gencrally in use throughout the date-growing areas of the Coachella Valley, the possibility of needing the protection before covers are normally installed might necessitate the use of some cover material that would not produce a rise in temperature within the bunch. Large-mesh cheesecloth, two types of plastic large-mesh sheets, and a plastic type screen, each allowing a considerable movement of air but having small enough mesh to prevent cicadas from reaching the dates, were placed over separate bunches on each of the 12 trees. The regular commercial-grade paper date bunch cover also was placed over one bunch per tree. These bunches were checked each week for evidence of cicada injury. No punctures were made on the strands in any of the above-mentioned covered bunches from the end of July until October, when the dates were picked. Uncovered bunches on the same trees had 25% to 80% loss, although these bunches probably suffered greater damage than normal since all the other bunches had covers of some type, depriving the females of oviposition sites.

Three date gardens in the area also were observed during the course of these bunch-cover trials. All the bunches in two of the gardens were covered with paper bunch covers shortly after the first of August, when egg laying was just starting.

Puncture rows were made on a few strands in each of these two date gardens before the bunch covers were installed. At the time of the first fruit pick, examination of 100 bunches in each garden showed that no new punctures were made after the covers were on and there was no evidence of fruit loss caused by cicada egg oviposition. Very little checking or "sunburning" resulted from the early placing of these bunch covers in the two gardens.

The third garden was approximately ½-mile from the others and the bunches were not covered until the middle of September. In this garden 100 bunches were examined and the number of shriveled or fallen dates resulting from cicada oviposition was estimated at about 15% of the total crop.

REFERENCES CITED

Bliss, D.E., D. L. Lingren, W. D. Wilbur and L. E. Vincent. 1950. *Second report on date-bunch covers and their relation to the fruit-spoilage complex of Deglet Noor dates. Date Growers' Inst. Ann. Rept.* 26: 7-15.

Stickney, F. S., D. F. Barnes, and P. Simmons. 1950. *Date palm insects in the United States. U.S.D.A. Circ. No.* 846.

[1]*Personal Communciation,* 1963, *from L. D. Anderson and H. H. Shorey.*

THINNING TRIALS ON 'MEDJOOL' DATES — POLLEN DILUTION AND CHEMICALS

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The 'Medjool" is the only date variety commonly thinned by hand from the strands. All other varieties generally grown in this country can be thinned satisfactorily by removing center strands from the bunch or by a combination of cutting back the strands at the tips and cutting out strands from the center of the bunch. The fruits of the 'Medjool', however, are so large at maturity that, with a normal set of fruit, many fruits are too crowded to be picked without damage and fruits are often misshapen by pressure from adjoining fruit borne on the same strand.

If satisfactory methods of thinning less tedious and expensive than thinning by hand can be devised, they are likely to be welcomed by 'Medjool' growers, especially in view of the rising costs of hand labor.

Because dates are hand pollinated, the most obvious substitue for hand-thinning is pollen dilution. Diluting viable pollen with dead pollen would reduce the proportion of viable to dead pollen grains so that only a part of the flowers would receive viable pollen. Thus, tests of various mixtures of viable and dead pollen should reveal the percentage of pollen necessary to fertilize the desired percentage of flowers, or rather to obtain the desired set of fertilized fruits.

Chemical thinning is another possible means of removing a part of the flowers or young fruits from the inflorescence. Several different chemicals are being used successfully to thin apples (1,2) and other deciduous fruits. Chemical thinning is effected with carefully adjusted concentrations of the several compounds used so that the more sensitive flowers or very young fruits are damaged and the less sensitive portion of the crop is left undamaged. The cause of the thinning action of the various chemicals used in thinning apples and other deciduous fruits is not well understood, but one substance, naphthaleneactic acid (NAA), supposedly causes embryo abortion in the seed of some of the young developing fruit and consequent shedding of the fruits. Apparently the weakest flowers or young fruits are subject to the greatest damage by the chemicals used for thinning so that increasing concentration increases the severity of thinning. Variations in weather and in vigor of the trees have caused some irregularities in response to the thinning compounds and consequently the work on chemical thinning of apples has been going on for the last 20 or more years. Hundreds of tests have been conducted to find the compounds best suited to different varieties, to reveal the various factors that influence the results of the treatments, and to improve control of the severity of thinning.

Tests of thinning 'Medjool' dates by pollen dilution were begun in 1961, and tests of chemical thinning were started in 1963. The results of these tests are reported in this paper.

MATERIALS AND METHODS

The thinning tests were conducted at the U.S. Date and Citrus Station, Indio, California, in a small square block of 49 'Medjool' palms well isolated from other plantings of dates from which pollen might be carried by the wind. In 1961, all trees except 2 on the southeast, or leeward, corner were pollinated with a mixture of 1 percent viable pollen and 99 percent dead pollen. The other 2 trees (controls) were pollinated with undiluted fresh pollen.

In 1962 and 1963, 7 control palms across the south (leeward) side of the block were pollinated with undiluted fresh pollen, and as soon as the bunches were tied down, they were hand thinned. In 1962, 21 palms in the northwest (windward) part of the block were pollinated with a mixture of 1 percent viable and 99 percent dead pollen, and in the northeast section 21 palms were pollinated with a mixture of 2 percent viable and 98 percent dead pollen. In 1963, 15 trees in the northwest section were pollinated with a pollen mixture containing 1.5 percent viable pollen, and 20 trees in the northeast section were pollinated with a pollen mixture containing 4 percent viable pollen. At each picking the fruit from each tree was field-graded into marketable fruit and culls and weighed.

A thinning trial using six chemicals was conducted in the spring of 1963. Half bunches on 7 trees in a row to the leeward of the trees in the pollen dilution tests were sprayed with a pressure-type hand sprayer at 1 or 2 or 4 weeks after pollination with 6 different chemicals at the respective concentrations in parts per million (ppm), listed as follows: Maleic hydrazide — 1,000, 100, 20, 10 ppm; 2, 4, 5-trichlorophenoxyacetic acid—1,000, 100, 20, 10 ppm; Naphthalene acetic acid—1,000, 100, 50, 25 ppm; Sinox (dinitro ortho secondary butyl phenol)—6,000, 1,500, 750, 375 ppm; Elgetol (sodium dinitro-ortho-cresylate) — 6,000, 3,000, 1,500, 750, 375 ppm; Sevin (1-naphthyl N-methyl carbamate) — 10,000, 5,000, 1000, 500 ppm. The other half-bunches were not sprayed but were hand thinned and kept as controls. Waxed paper was used to separate the bunch halves prior to spraying and was left until the sprayed half was dry The bunches were inspected in May, June, and August and the thinning estimated as the percentage of the normal set removed.

RESULTS

In 1961, when the control trees were not hand thinned, the set of fruit resulting from pollinating with a pollen mixture containing 1 percent viable pollen was very low (Table 1) and while the average fruit size on the thinned trees was about double that on non-thinned trees, the yields of the thinned trees were quite low, being less than half that of the control trees.

In 1962 and 1963, the control trees were hand thinned. The fruits on trees that received 1 percent viable pollen in 1962 were slightly larger than those that received 2 percent viable pollen; and the fruits on the thinned trees were slightly larger than those on the controls, which were not thinned early enough to produce the full effect to be expected from hand thinning. The average total yield of the control trees was considerably greater than that of the trees thinned by pollen dilution.

Table 1. The relation of fruit size and yield per tree to percentage of viable pollen used for pollinating trees in 1961, 1962, and 1963.

Year	Viable pollen (percent)	Weight per fruit (grams)	Fruit per pound (no.)	Yield pounds per tree		
				No. 1	Culls	Total
1961	100	11.9	39	59	59	118
	1	22.1	20	31	18	48
1962	100[1]	18.8	24	119	18	137
	1	23.8	19	62	7	69
	2	21.9	21	81	9	90
1963	100[1]	18.9	24	175	37	212
	1.5	21.6	21	161	33	194
	4	19.8	23	162	42	205

[1]Control—hand thinned

In 1963, size of fruit on trees thinned by pollen dilution was somewhat greater than those of the controls, probably because of late thinning of the controls, and the average yield of trees thinned by pollen dilution was almost equal to that of the controls.

In the tests of thinning by treatment with chemicals in 1963, Maleic hydrazide and Sevin had no apparent effect at any concentration used (Table 2). Sinox burned the strands badly at all concentrations which caused any thinning: at 6,000 ppm all strands were burned and killed; at 1,500 ppm the bottom one-fourth to one-half of the strands were burned and this effected the 25-50 percent thinning which was observed. Concentrations of 750 and 375 ppm had no apparent effect. 2,4,5-T at 1,000 and 100 ppm completely stopped the growth of the fruit, which remained green and stayed on the strands for several months but did not increase in size. Good thinning resulted from sprays at concentrations of 10 and 20 ppm applied 1 week after pollination and one spray at 10 ppm applied 2 weeks after pollination. NAA at 1,000 and 100 ppm completely defruited the strands. NAA sprays at concentrations of 50 and 25 ppm effected sporadic thinning varying from 9 to 90 percent. Good thinning was obtained with Elgetol at all concentrations applied 1 week after pollination except that of 6,000 ppm and at all concentrations applied 2 weeks after pollination. Little or no effect was obtained with the sprays applied 4 weeks after pollination.

Because of the range over which Elgetol effected good thinning, an expanded experiment using whole trees was conducted during 1964. Although the sprays of NAA and 2,4,5-T applied 1 and 2 weeks after pollination gave good results in some cases, the results were sporadic enough to cause some doubt as to the commercial adaptability of these sprays at these intervals. Because of the results obtained with NAA applied 4 weeks after pollination, however, and the possibility of its being commercially usable as a one-spray application after pollination was completed, it was also tried on whole trees in 1964.

DISCUSSION AND CONCLUSIONS

The results of these tests do not justify any recommendations for thinning by pollen dilution or by use of chemicals. Both methods used show some promise and the results suggest that further work should be carried out. It seems likely, however, that chemical thinning will eventually prove to be the more satisfactory method. The pollen dilution method has several serious faults: (a) pollen can be blown from nearby trees of varieties that are pollinated in the usual manner; (b) to be sure of an adequate set of fruit probably too much viable pollen will have to be used, thus necessitating considerable hand thinning; (c) in an unfavorable season the use of heavily diluted pollen might result in a crop failure. Chemical thinning also presents hazards; for example, some infloreseences are killed; over thinning or under thinning may result from variations in weather conditions or variable vigor of the flowers. The most hopeful possibility for early commercial use of one or both of the thinning methods is underthinning, but thinning enough to reduce somewhat the amount of hand thinning needed.

SUMMARY

Fruit thinning trials on the 'Medjool' date were conducted by 2 methods: (1) dilution of viable pollen with dead pollen; (2) spraying young fruits with chemicals at 1 to 4 weeks after pollination.

Application of pollen mixtures containing 1 to 4 percent viable pollen resulted in slightly smaller yields than hand thinning and increased average fruit size to about the same as that on hand-thinned trees.

Maleic hydrazide at 1,000 to 10 ppm and Sevin at 10,000 to 500 ppm caused no thinnning; Sinox at concentrations that caused thinning burned the strands; 2,4,5-T produced good thinning at 10 and 20 ppm; NAA at 50 and 25 ppm effected highly variable thinning; Elgetol effected good thinning when applied 1 or 2 weeks after pollination at concentrations of 3,000 to 375 ppm.

LITERATURE CITED

1. *Batjer, L. P. and M. B. Hoffman.* 1951. *Fruit thinning with chemical sprays. U. S. Dept. Agri. Cir.* 867 *pp.* 1-46.

2. *Thompson, A. H.* 1957. *6 years' experiments on chemical thinning of apples. Maryland Agr. Exp. Sta. Bul. A*-88 *pp.* 1-46.

Table 2. The estimated percentages of fruit thinned from half-bunches by spraying with various concentrations of chemicals.

Chemical	Concentration (ppm)	Weeks after pollination 1	2	4
		(Percent thinned)		
Elgetol	6,000	90	50	10
	3,000	60	60	10
	1,500	60	50	0
	750	40	20	0
	375	60	30	0
NAA	1,000	100	100	100
	100	100	100	90
	50	40	90	60
	25	0	60	40
2,4,5-T	1,000	100	100	100
	100	100	100	70
	20	50	95	10
	10	50	60	10
Sevin	10,000	0	0	0
	5,000	0	0	0
	1,000	0	0	0
Sinox	6,000	100	100	100
	1,500	50	25	50
	750	0	0	0
	375	0	0	0
Maleic hydrazide	1,000	0	0	0
	100	0	0	0
	25	0	0	0
	10	0	0	0

PROGRESS IN MECHANIZATION OF DATE HARVESTING

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In the winter of 1960, the date industry of California, through the Date Administrative Committee, expressed an interest in harvest-mechanization research to the University of California and the U. S. Department of Agriculture. Work on the project was formally started in the fall of 1961 when research personnel reviewed the harvesting operations at Indio*

The main problem was to develop harvesting methods which would substantially reduce labor requirements and, hopefully, total harvesting costs. Because labor used for cultural and harvest operations is obtained almost exclusively through the Mexican National Labor program, the industry, as a whole, is deeply concerned about availability of labor after the probable termination of this program in the near future.

Over the years, the method of harvesting had remained much the same. The conventional method was selective hand-picking of mature fruits. Harvesting and handling of fruit were usually done by a two-man team per palm. The men would enter the palm by means of a 48 to 60 foot extension ladder, then pick the fruit from a bosun's chair supported by chains hooked on the palm fronds. Fruit was picked into buckets, which when full, were lowered to the ground with ropes. All handling and hauling of picked fruit were done in L. A. lugs (small wooden boxes holding about 30 pounds of fruit). The total number of picks had been reduced from 8 or more to 2 or 3 with a clean-up, to save labor. This method had almost reached its ultimate in efficiency, and a complete harvest in one picking would not greatly reduce total harvesting costs.

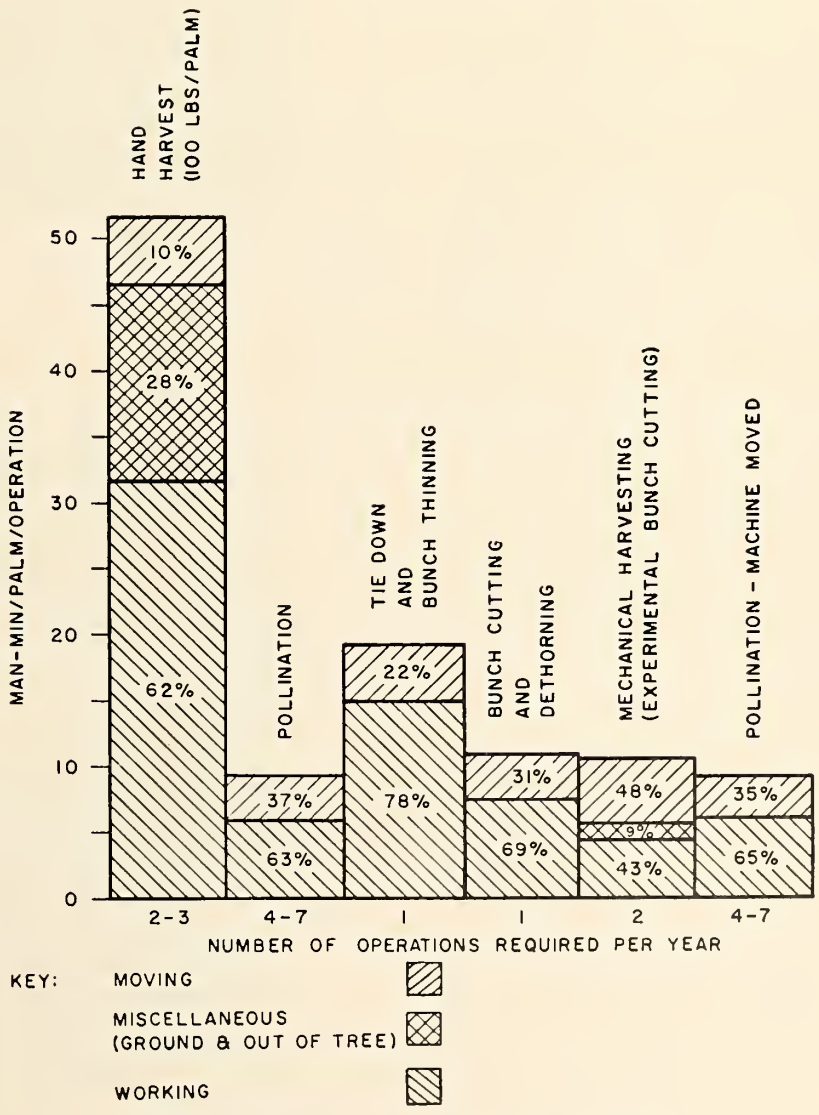
Harvesting costs under the conventional picking system represented approximately 45 percent of the total cultural cost, although harvesting was only one of some 10 major operations(6).

PRELIMINARY OBSERVATIONS AND STUDIES

Time studies and observations of selective picking with a ladder and a taxi method of moving men from palm to palm were made to determine harvesting rates of each method, time required for each operation, and problems encountered with each method. The studies indicated that simply moving the pickers from palm to palm with a machine instead of a ladder, and continuing the same selective hand pick did not increase harvesting rates and, therefore, did not justify use of the machine. Factors which contributed to this lack of improvement were:

1. Differences in the amount of fruit harvested from each palm caused unplanned moving of the pickers or excessive waiting before the pickers could be moved.
2. More workers were required to perform ground operations, although fruit was picked at the same rate as that of the ladder crew.
3. Two men (picker and taxi driver) were involved in each move, instead of one man as in the ladder method.

Field observations of conventional picking operations revealed that, while picking was intended to be selective by individual mature fruits, it actually tended to be somewhat selective by mature bunches, with the pickers



LABOR ALLOCATION IN VARIOUS OPERATIONS

FIGURE 2

*Since Deglet Noor is the principal variety, representing over 90% of the volume of production, it is the only variety now being considered for mechanization.

working only on the most mature bunches. This suggested the possibility of a harvest by bunches.

A review of the literature on the subject of delayed harvest, fruit quality, storing quality, and market preference indicated that Deglet Noor (1, 2, 4, 7, 8) did not deteriorate during delayed harvest but did dry to a lower moisture content which resulted in a decreased percentage of top yield in Top Natural and Select Natural grades. This decrease in moisture may not be serious, however, since reports indicate that keeping quality and market appeal of hydrated dates are generally higher than in non-hydrated dates.

A study of the effects of bunch harvesting was made by the U.S. Date and Citrus Station (5). This study revealed that Deglet Noor could be harvested by the bunch with little difference in grades from a conventional hand pick if 2-pick bunch harvesting was employed.

APPROACH TO MECHANIZATION

Based on the field observations and literature reviews by engineering personnel, an experimental "bunch" method of harvest was proposed in which only mature bunches would be harvested the first time through the garden and all remaining bunches the second time through. The fruit would be rapidly removed from the bunches by mechanical removal equipment.

Fruit removal tests were made at the University of California, Davis, and later at Indio. Of the removal methods tried, vertical vibration of the bunch was found to be the most desirable method from the standpoint of: 1) time required for 100% removal; 2) fruit condition and appearance after removal; 3) simplicity of of operation.

Bunch harvesting can be accomplished either by cutting bunches and removing the fruit later, or by removing the the fruit without cutting the bunch. The bunch-cutting method was selected as the first step, with fruit removal at the palm to be investigated as more information became available.

Observations and time studies of conventional picking were made to determine harvesting rate, time required for each operation and problems encountered. Summaries of these results are presented in Figure 2.

In addition, handling and storage tests (9) were made in conjunction with the industry and the USDA Market Quality Research Division at Pomona, California, to determine the possibility of using bulk containers. These tests indicated bulk containers could be used to a depth of 18 inches without appreciable damage to the fruit during storage.

MECHANICAL HARVESTING SYSTEMS

Two experimental harvesting systems were proposed and designed after a joint meeting with the date industry.

Figure 3. A date tower being moved to the next set of palms during harvesting.

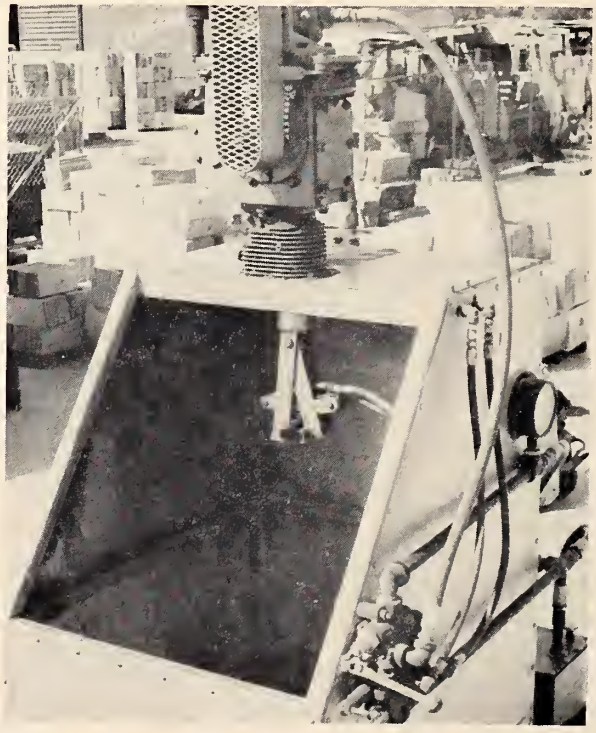


Figure 4. Vertical vibrator, clamp and controls used in bunch cutting systems.

In the first mechanical harvesting system, the primary objective was to evaluate two different systems of bunch handling: 1) removal of fruit from the bunches on the tower while working in the garden; 2) transport of bunches to a central location, serving several harvesting operations, for removal of the fruit.

One system made use of an existing "date tower" owned by a grower. Although the tower had not been used for several years, its basic components were retained. New catwalks, as well as fruit lowering, fruit removal, bulk bins and hydraulic power equipment were designed and installed in cooperation with the owner and a cooperative packer. This tower (Figure 3) is operated straight down the row between 2 rows of palms, removing all the mature bunches from the 2 opposite palms at each stop. Two men at each palm are raised on catwalks by sectional hydraulic cylinders. From the catwalks, bunches are cut, then lowered to the bottom of the tower where they are placed in a vertical vibrator and the fruit shaken off into bulk bins. The full bins are dropped in the garden and later placed on a truck by a fork lift, then taken to the packing house. Eight men in the field were required to operate this system during the 1962-63 harvest season.

A second system used a commercially available tower to place one man in position to cut mature bunches which were placed in a specially built basket. During moves from one palm to another, the cut bunches were emptied from the basket to a waiting trailer. Full trailers were hauled to a central location where fruit was removed from the bunch by a vibrator identical to that used in the first system. Three men in the field plus 3 men at the packing house were required to operate this system.

The vibrator (Figure 4), designed for use with both systems, is an oil-bath-lubricated, hydraulically-powered unit which is rigidly mounted and delivers a 3¼-inch vertical stroke to the bunch at 600 to 1100 cycles per minute.

RESULTS AND SYSTEM PERFORMANCE

During the 1962-63 harvest season, approximately 1.5 million pounds of fruit were harvested by the bunch method.

An average time of 8 seconds is required to shake a bunch (2 seconds for fruit removal), resulting in a shaking rate of 7.5 bunches per minute. All the fruit is removed from the bunch in this time, with no apparent fruit damage. A vibration frequency of 600 to 700 cycles per minute is adequate and more desirable than higher frequencies for the stroke used.

Time studies of the experimental systems in operation under comparable conditions and quality evaluation of the mechanically harvested fruit (3) by the U. S. Date and Citrus Station at Indio, California, show bunch harvesting to be feasible.

A system which uses bunch cutting followed by fruit removal in the field and bin hauling of loose fruit proved to more desirable from cost and labor standpoints than a system in which cut bunches are hauled in trailer lots to a central shaking installation for removal of the fruit. The main objections to the latter system are:

1. Double handling of the bunches requires excessive time and labor.
2. Fruit hauled to the packing house in small lots, requiring several scheduled trips and trailers to keep the field operations going and thus increasing costs of transporting the fruit.
3. Significant fruit damage and trash accumulation result from hauling bunches of fruit in trailers and removing them from the trailers.

These problems offset any advantage in centralizing the shaking operation.

A summary of the 1962-63 timed results for the system using bunch cutting, field shaking and bin hauling is given below. These figures are for the average hourly performance when 125 pounds of fruit (8 bunches at 15.6 pounds each or approximately one-half the total yield) are cut from 32 to 40-foot palms: total pounds harvested per hour 5,770; pounds harvested per man-hour 720; acres harvested per hour 0.96; palms harvested per hour 46.0.

During the 1963-64 harvest season, several changes were made in the previously used systems and, in addition, 2 new systems for harvesting at the palm were tried. In the first case, the vibrator and tower previously used in the central shaking system were used in a field shaking system with loose fruit hauled in bulk bins. Each tower employed a shaker truck which carried the vibrator and bulk bin handling equipment. This method requires only 3 men in the field and theoretically attains 860 pounds per man-hour under the conditions previously stated. Furthermore, minor changes were made on the 1962-63 field shaking system which reduced the required crew size to 7 men and theoretically raised the harvest rate to 825 pounds per man-hour while maintaining the previous acreage rate.

HARVESTING AT THE PALM

Information gained during the 1962-63 harvest season prompted investigation of the feasibility of harvesting at the palm, i.e., (removing the fruit without cutting the bunch. The main purposes of developing a method of mechanical fruit removal at the palm are to: 1) eliminate the need to cut and handle the mature bunches; 2) reduce crew size required per tower; 3) reduce the amount of

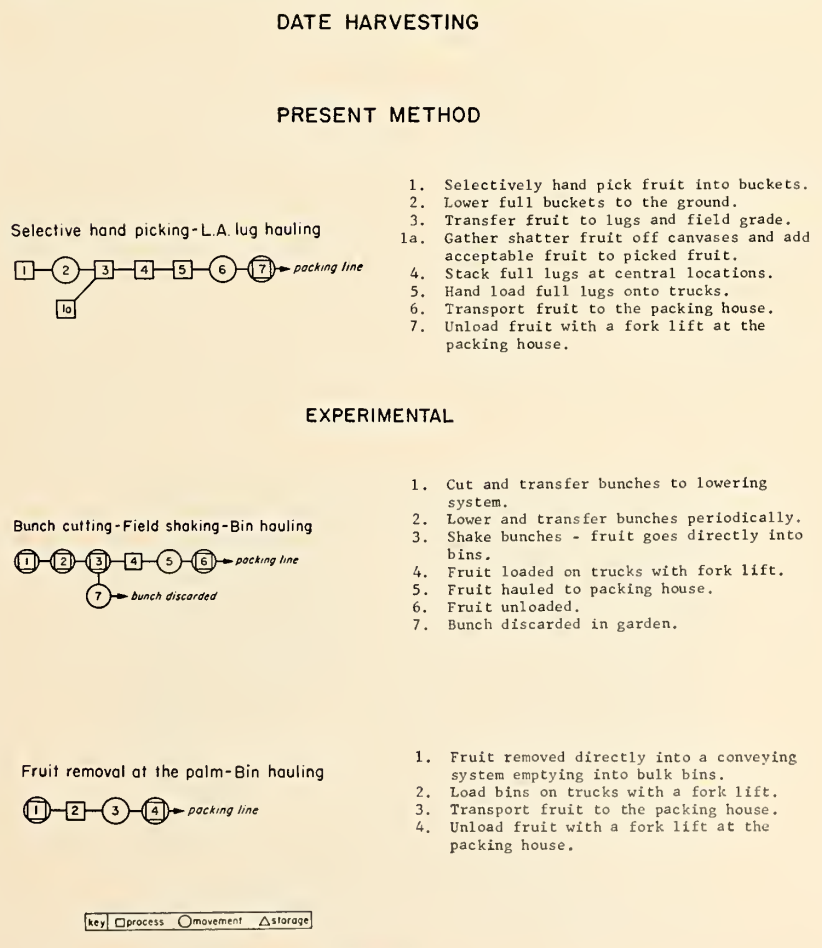


FIGURE 1

accompanying equipment required with some types of towers when harvesting by bunch cutting. Figure 1 shows the steps involved in harvesting and moving fruit to the packing house by both conventional and experimental harvest method.

One important possible disadvantage in harvesting at the palms is slowing down the harvest operation more than can be economically justified as compared to the bunch-cutting method.

Tests to obtain design information were performed in October 1963 on fruit considered by a cooperative's field department to be typical and ready for harvest by the bunch method. These tests revealed that in 2 to 3 seconds all the fruit could be removed from mature bunches weighing up to 30 pounds. In addition, the vibrator used to accomplish this could be lighter in weight than average bunches handled in the bunch-cutting method of harvest.

A hand-carried bunch vibrator (Figure 6) was designed, constructed, and used in commercial harvesting. The vibrator weighs 12.5 pounds and is hydraulically powered. It is attached to the bunch stalk, just above the last fruit strands, by means of the "C" type clamp. Switches located in the carrying handles and on the hoses control the clamping action and vibrator motor, respectively.

The use of this unit requires that the operator be supported on a platform or bucket which has a means of collecting the fruit as it is harvested. This method of harvesting has its greatest advantage when the operator is free to move around while selecting and harvesting the mature bunches.

In addition, a new 2-palm tower (modified from a commercially available piece of equipment) was used experimentally by one of the cooperatives. This machine employed a straight-down-the-row operation, using 2 mechanically operated booms to position the men in the working areas for at-the-palm harvesting. Fruit removal was accomplished with a "knocker" similar to one developed by the cooperative during the 1962-63 harvest. This knocker used an electrically driven eccentric to produce a reciprocating horizontal motion which was transmitted through a flexible shaft and then impressed on the bunch by means of a yoke which slipped over the bunch, (Figure 5). The fruit was collected in a funnel and chuted to a bulk bin located at ground level A 5-man crew was required to operate the machine. No time studies are available for comparison of this type of operation, but theoretical calculations indicate that with modification to allow the picker more freedom of movement around the tree for selection of bunches, it should perform in the same range as the bunch-cutting, field-shaking method.

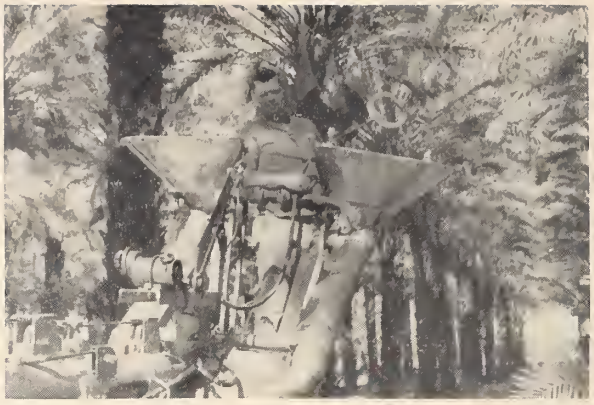


Figure 5. Fruit "knocker" and loose fruit catching devices.

In the development of the mechanical harvesting systems, the possibility of continuing to use ladders, instead of the expensive towers, to enter the palms and cut the mature bunches was considered. A system similar to this was used by a grower this past season. Limited observations were made and figures obtained from the grower.

DAMAGE STUDIES

A damage study to evaluate and compare damage and other undesirable effects caused by each system of harvesting was conducted during the 1963-64 harvest season. This involved the establishment of test blocks at various locations in the valley. In these locations, fruit was harvested by 4 methods: 1) hand harvest, 2) bunch cutting and field shaking, 3) in-tree removal with the knocker, 4) in-tree removal with the vibrator. The results from each method were evaluated and compared, but the information is too variable to draw any significant conclusions. Further evaluations will be made and results, if significant, reported at a later date.

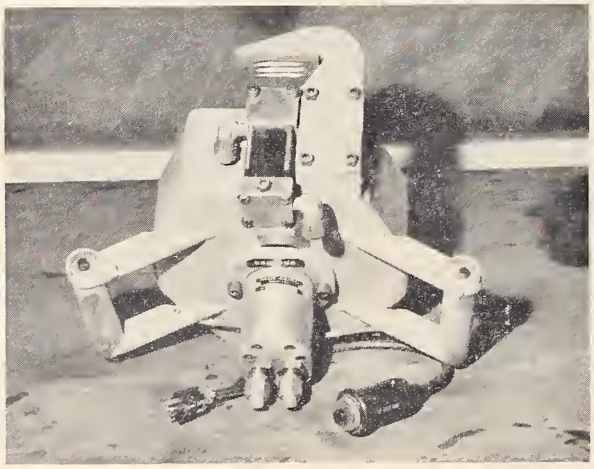


Figure 6. Hand carried bunch virbator

HARVEST METHODS FOR VARIOUS SIZE OPERATIONS

During the past 2 years of field work and planning, many methods and systems for harvesting have been considered, and several of these have been used for varying periods of time. From results of time studies, system changes, and observations, the following theoretical conclusions have been made:

Commercial or Cooperative Harvesting: For commercial harvesting, it is assumed that:

1. A 2-pick bunch method of harvest is used in which about one-half of the yield, or 6000 lb/acre, is harvested during each pick.

2. All harvesting systems will be operated for the entire harvest season (approximately 12 weeks at 50 hours per week.)

3. Adequate equipment is used so that first and second pickings can be made at the time required.

A harvesting system in which workers climb ladders, cut and lower mature bunches while supported by a conventional picking seat, for mechanical removal of the fruit into bulk bins has no commercial importance. It is a relatively inexpensive way of increasing the harvesting rate over hand picking; however, the acreage rates and acres per season obtainable by such a system are very low compared with the systems in which towers are used. The labor force is reduced by only about 50% compared to hand picking whereas some tower systems can reduce the labor force by as much as 80%. Also, harvest costs

per pound cannot be reduced as much with the ladder methods as with the tower methods.

Systems which use towers and are based on bunch cutting and fruit removal from the bunch in field are at present slightly more desirable from a harvesting cost standpoint than the systems which use towers and harvest at the palm. However, as indicated, this difference appears slight and is due primarily to the lower harvesting rate (acres per hour) when harvesting at the palm. It should be possible to improve this by positioning the worker harvesting fruit so he can work as fast as he selects bunches and the fruit is removed. At present, the worker must wait to be positioned for each bunch or has to reach for many of the bunches. Also, in some cases, an extra worker is required just to assist in unloading the harvested fruit. It appears that changes to correct these conditions will be necessary in order to make harvesting at the palm more desirable than bunch cutting.

The large 2 and 4 palm towers, which have been used as aids to hand picking in the past, could, in most cases, harvest for the least cost per pound if they were used to their capacity with respect to acres harvested and hours worked per season. However, the geography of the date industry, average garden size, and layout of most gardens practically prohibit commercial acceptance of this type of machine. It is impractical to move the present large towers considerable distances or frequently during harvesting.

Grower Harvesting: The grower considering mechanization must decide whether it is to his advantage to have his fruit harvested on a contract basis or to invest in harvesting equipment of his own. Important factors in this choice are: 1) cost of contract harvesting; 2) acreage to be harvested; 3) time in which the harvest must be completed; 4) availability of labor. By assuming that a) a 2-pick bunch method of harvest is used in which about one-half of the yield, or 6000 lb/acre, is harvested during each picking, b)a 3-week interval exists between the beginning of the first and second pickings (50 hours of work per week), and c) because harvesting at 1.0 cent per pound is available from an outside source, the grower's harvest cost using his own equipment and labor may not exceed 1.0 cent per pound, the following acreages may be harvested by the respective systems previously described under commercial harvesting. (The lower and higher figures represent, respectively, the minimum acreage which can be harvested without exceeding a cost of 1.0 cent per pound and the maximum acreage which can be harvested in 6 weeks of continuous harvesting.)

1. Seventeen to 25 acres for a system using ladders and mechanical removal of fruit into bulk bins. This method is most productive in gardens not exceeding about 35 feet to the position of the worker in the palm.

2. Twenty-five to 45 acres for a system of harvesting at the palm from a single palm tower which uses a 2-man crew.

3. Forty-five to 65 acres for a system of bunch cutting from a single palm tower followed by fruit removal in the field. This is similar to the system which employed a single palm tower, shaker truck, and 3-man crew during the 1963-64 harvest season.

4. Sixty-five to 145 acres for the system of bunch cutting from a 2-palm tower followed by fruit removal into bulk bins in the field.

These conclusions are dependent on the average acreage rates actually attained. Also, a grower may be able to justify more elaborate equipment and/or realize lower harvest costs by harvesting in early and late maturing areas of the valley, thus increasing the hours of equipment use and acres harvested per season.

SUMMARY

The type of harvest system chosen must depend upon several variables: size and geographical location of acreage concerned, availability of labor, and consideration of remaining cultural practices. What is most desirable for one grower may be completely undesirable for another. Moreover, the advent of mechanization may bring about greater use of contract harvesting.

While the mechanical harvesting of dates is now a reality, there is need for further development of the various machines and systems to achieve their ultimate efficiency. These changes will be in rapidly positioning the man working in the palm, while allowing him the largest degree of freedom of movement around the palm, and in handling fruit after it is harvested.

The greatest concern and effort should now be directed to other cultural practices and reduction of cost and labor requirement in these. Pollination should be the prime area since it is the second highest labor-using operation. Each area must be investigated in the light of the other operations to determine how they may be coordinated into a complete cycle of operations. The ideal solution to the overall problem would give a balanced labor force throughout the whole season, eliminating the peaks of high seasonal labor requirements, and thereby making it possible to maintain a trained and efficient labor force.

LITERATURE CITED

1. *Furr, J. R., and W. W. Armstrong. 1954. An investigation of the relation of frequency of picking Deglet Noor dates to grades, picking costs and returns. Date Growers' Inst. Rpt. 31: 10-12.*

2. *Nixon, R. W. 1959. Growing dates in the United States. U. S. Dept. Agr., Agr. Infor. Bul. 207, 50 pp., illus.*

3. *Nixon, R. W. 1963. Quality of Deglet Noor dates in relation to method of harvesting. Date Growers' Inst. Rpt. 40: 10.*

4. *Nixon, R. W., and J. R. Furr. 1961. Quality of Deglet Noor dates in relation to frequency of picking. Date Growers' Inst. Rpt. 38: 14-15.*

5. *Nixon, R. W., and J. R. Furr. 1962. Frequency of picking in relation to quality of Deglet Noor dates in 1961. Date Growers' Inst. Rpt. 39: 16-18.*

6. *Phelps, H. F., and D. D. Halsey. 1956. Date garden management—cost and income 1954-55 season. Univ. of Calif. Extension Service, Riverside, Calif. 5 pp. (Mimeographed)*

7. *Rygg, G. L. 1950. Investigations on harvesting Deglet Noor dates including bunch cutting and delayed picking. Date Growers' Inst. Rpt. 27: 22-25.*

8. *Rygg, G. L. 1954. Quality of dates in some American markets. Date Growers' Inst. Rpt. 31: 20-26.*

9. *Rygg, G. L. 1963. Experimental storage of date in bulk bins. Date Growers' Inst. Rpt. 40: 8-9.*

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POLLINATING DATES BY AIRPLANE

By R. D. Preston

Coachella, California

Pollinating date trees requires hand labor and several trips up a ladder at each tree. The possibility of losing labor that is willing to climb ladders and accomplish the necessary work in the tree has many growers searching for new and different methods of tree work.

Pollinating and harvesting required the highest number of men to complete the work in the yearly cycle. It is often difficult to keep ahead of the work of pollinating during the peak bloom when good labor is available. With the reduction of labor in mechanical harvesting being demonstrated during the 1962 season, a change in pollinating practice seemed most important. Pollinating by airplane appeared to be a possible answer to this problem.

Preparations began in February 1963 to set up a test plot. A garden of 114 trees, or approximately 2¼ acres, in Oasis was selected because it is remote from other date trees. The garden included only one male tree which could be easily cut back to eliminate an outside source of pollen. The general health of the trees was good and the grower was willing to chance a crop failure in the interest of the test.

The first problem was to conserve the amount of pollen dispersed. If the amount of pollen required for application by airplane should exceed the available supply, obviously this method would prove impracticable.

Ground walnut hulls and wheat flour were used as pollen diluents. Both materials had been used or tested previous to this season with pollen. In the first group of applications pollen was diluted with walnut-hull dust.

The first application was completed on March 7, 1963, at approximately 9:30 a.m. A mixture of 10 ounces of pollen and 10 pounds of walnut dust was applied over the entire garden. On this date only 5 spathes were open.

The second application was a mixture of 1 pound of pollen and 10 pounds of walnut dust. Scattered over the garden on this date, 35 new spathes were cracked or open.

A mixture of 10 percent pollen and 90 percent diluent was used in the remaining application. On the third application it was noted that spathes tagged on March 14 had not completely opened.

Estimates of the percentages of a normal set of pollinated fruit that resulted from the different applications of diluted pollen were made by two observers who climbed each tree and estimated the percentage of a normal set on each bunch. The set of pollinated fruit on individual bunches ranged from 0 to 90 percent. The percentages of a normal set of pollinated fruit obtained on the inflorescences tagged on each date of pollen application ranged from about 16 to about 55 percent. (Table 1). The average was 44.4 percent.

The total amount of the 1963 crop harvested from the garden was 38,403 pounds. There were 25,940 pounds of culls and 12,463 pounds of marketable fruit. The 114 trees carried a total of 1,258 bunches, or about 11 bunches of approximately 30 pounds each per tree. The high percentage of culls resulted in large part from rain damage to the fruit, none of which was protected by covers.

The results show that the poor pollination periods were early and late in the season. The low percentages of pollinated fruits cannot be explained by any of the conditions evaluated. Low temperatures and slow opening of the spathes suggest a reason for the early poor set. However, the maximum daily temperature after March 18 was 70° F. or above, except one day, April 17. Under normal conditions this should have been sufficient for a normal set of fruit. Also the last two applications were made in temperatures well above those required and still resulted in a poor set.

Pollen diluted with walnut-hull dust and pollen diluted with wheat flour had high and low percentages of pollination and therefore seemed equally effective.

Table 1. The amounts of pollen and diluent used on different dates and the estimated percentage of a normal set of fruit obtained from each application.

Date 1963		Pollen (pounds)	Diluent (pounds)	Pollinated[3] (percent)
March	7	0.6	10.0[1]	.....
	14	1.0	10.0[1]	17.7
	20	1.0	9.0[1]	22.4
	26	1.0	9.0[1]	37.6
April	3	1.0	9.0[1]	39.1
	10	1.0	9.0[1]	55.4
	18	1.0	9.0[2]	35.4
	22	1.0	9.0[2]	28.0
	29	1.0	9.0[2]	36.9
May	6	1.0	9.0[2]	16.4

[1]Walnut hull-dust

[2]Wheat Flour

[3]Estimated percentage of normal set of pollinated fruit.

Since the low percentage of pollination occured when few spathes were open early and late in the blooming season and the high percentage occurred during the highest incidence of new blossoms, it was decided to use hand pollination early and late and airplane applications of pollen in midseason. If this approach is successful, it would substantially reduce the number of men needed during pollinating.

Date Growers Institute Membership as of August 18, 1964

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Date Administrative Committee ..... Indio
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Dr. Rodney H. Snow — Santa Monica
Solore Ranch — Thermal
Edward C. Stock — Thermal
Joseph Strehle — Longview, Washington
Mrs. Walter T. Swingle — Berkeley
Tall Palms Ranch—David Mitchell — Indio
Lawrence G. Thielemeir — Santa Ana
Thunderbird Park, Inc. — Cathedral City
W. E. Urick Ranch — Los Angeles
U. S. Date Field Station — Indio
Valley Center Ranch — Palm Desert
Edith E. Wark — Palm Desert
Norman A. Waters — Chicago, Illinois
Webb Farms, Inc. — Thermal
Robert W. Webb, Jr. — Palm Springs
James P. Westerfield — Mecca
Hollis White — Rancho Mirage
Gwynn Wilson — Palm Desert
Wooden Shoe Ranch—Bernard Van der Steen — Indio
Forrest O. Young — Redlands
Zapp-Grandy — Vancouver, Washington
Stanley and Selma Zarakov — Palm Springs